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PUBLISHERS' ANNOUNCEMENT

THIS 1958 Progress Volume is the eighth of an annual series of supplements to *British Surgical Practice.* By this means the eight volumes of the main work are kept up to date in the ever increasing field of surgical knowledge, by original articles, critical surveys and abstracts.

The original articles are followed by general surveys of selected systems and specialties; these surveys are followed by abstracts relating to the subject.

The Noter-up section will guide the reader from the main work to the supplementary material which appears in this or previous Progress Volumes. The purpose of the Noter-up remains the same as in previous years. The reader should first of all refer to the material in the main volumes of *British Surgical Practice.* Then, in order to ascertain the advances and changes which have been discussed in this or previous Progress Volumes, he should refer, under the same heading or key number as that consulted in the main work, to the Noter-up in the latest Progress Volume. There he will find details of the articles, surveys and abstracts relating to the subject which have appeared in the Progress Volumes. Regional or system surveys naturally cover a wider field than in previous volumes and individually apply to more than one chapter in *British Surgical Practice.* Because of this, the main subject headings within the surveys have been linked in the Noter-up to the appropriate chapter titles of the main work. Thus by reference to the Noter-up, the reader of the main volumes is easily able to locate any new material on a particular subject even though it may be contained within a survey. The nature of surgical advance has necessitated the inclusion of new titles in the Noter-up, and for convenience and ease of reference, these are as follow: Abdomen; Antibiotics; Brain—Vascular Anomalies; Carpal Tunnel Syndrome; Collagen Diseases; Electronics; Fluid and Electrolyte Balance; Gynaecology; Kidney and Ureter—Nephrectomy; Kidney and Ureter—Surgical Aspects; Lung—Surgery; Obstetrics; Organ Transplantation; Pelvic Organs—Viscerectomy; Pituitary Gland; Plastic Surgery—Correction of Facial Deformity; Thorax—Congenital Deformities; Ureter—Replacement of.

PUBLISHERS' ANNOUNCEMENT

Non-subscribers will find the Noter-up section of value in that it is alphabetically arranged and gives at a glance information as to the presence or absence of recent material on any particular subject. Consequently, the book can be used independently.

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CONTENTS

INTRODUCTION

THE MATERIAL in this Progress Volume may be classified under three headings: subjects which have not appeared previously in *British Surgical Practice*; subjects which have been dealt with before but which need to be brought up to date; and critical reviews of current surgical literature.

In the first category are the collagen diseases which, though perhaps primarily "medical" frequently confuse surgical diagnosis; operative cholangiography, the use of which is still a matter of opinion and argument; the carpal tunnel syndrome, which can be so simply relieved provided the diagnosis is beyond question; the use of the ileum in urology, requiring mature surgical judgment based on sound physiological principles; and preclinical carcinoma of the cervix, a condition the nature of which is still open to dispute, but which is convincingly portrayed by Professor Carey of Auckland.

In the second and largest group are blood transfusion, fluid and electrolyte balance,. Crohn's disease, the indications for and management of ileostomy for ulcerative colitis, the surgery of the oesophagus, septal defects in the heart, the surgical induction of labour, the management of acute head injuries, and the surgery of glaucoma and of the spinal cord and cervical rib. All these subjects have been described in *British Surgical Practice*, but since the original articles were written advances have been made in treatment based on a better understanding of the pathology of the diseases or of their effects upon physiological processes in the body, and therefore the time has come to bring the articles up to date.

Finally there are thoughtful critical surveys of recent work in the surgery of the stomach and duodenum, in pulmonary surgery and in the surgery of the central nervous system, and it is our hope that our readers will benefit, not only from the opinions expressed by the authors of these articles, but also from the abstracts of current literature which are appended to many of the chapters

An introduction is scarcely necessary—the list of articles with the names of their authors is an introduction in itself; but it is necessary for us to express to those who have so generously given their time and their thought to the preparation of these articles our deep appreciation of and gratitude for their understanding and co-operation.

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COLLAGEN DISEASES

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INTRODUCTION

The term collagen diseases was introduced following the work of Klemperer, Pollack and Baehr (1942), Klemperer (1950), who observed that in a number of diseases of unknown aetiology the common pathological finding was the presence of fibrinoid necrosis and perivascular infiltration Klemperer was careful to emphasize that a single end organ response did not of necessity indicate a common aetiology Initially, however, he did suggest that fibrinoid was a degenerative form of collagen or at least derived from collagen break-down and by so doing stimulated interest in the study of the connective tissue system Some authors use the term collagen disease or collagen disorders to include any disease with widespread involvement of the connective tissue system even if other tissues or whole organs are involved It is customary to group rheumatoid arthritis, acute and subacute disseminated forms of lupus erythematosus, polyarteritis or periarteritis nodosa, scleroderma and dermatomyositis as collagen disorders Some authorities extend the list to include rheumatic fever, serum sickness, ankylosing spondylitis, thromboangiitis obliterans and malignant nephrosclerosis

These disorders have many features in common They usually run protracted clinical courses, with remissions and relapses, but occasionally present as an acute fulminating illness Arthralgias, arthritis, deformity, skin lesions of the most varied character, albuminuria, renal disease, general malaise, anaemia and loss of weight are common clinical manifestations. It is very largely on account of the arthritic [illegible] non, that

[illegible] workers, notably Bien and Ziff (1951), have shown that collagen fibril degeneration plays little part in the formation of fibrinoid, whereas Strukov and Orlovskaya (1957) considered that the break-down products of collagen, particularly the mucopolysaccharides, contribute greatly to the formation of fibrinoid. Glynn and Loewi (1952) have shown that fibrin contributes very little to the formation of fibrinoid; but there is little doubt that blood products and mucopolysaccharides, probably from the connective tissue matrix, contribute towards the formation of fibrinoid

material. The other pathological feature stressed by Klemperer, perivascular infiltration, is likewise not confined to the collagen disorders.

Nature of the connective tissue system

The mistake has been in focussing attention upon the collagen fibres and fibrils, important though they are, both qualitatively and quantitatively. The connective tissue system also contains other fibres, elastic and reticular; cells, fibroblasts, histiocytes and mast cells, and matrix. Recent research has concentrated upon the fibre components. Astbury and Bell (1939), as a result of their investigation into the structure of protein fibres, were able to divide them into two main groups, the k.m.e.f. (keratin, myosin, epidermin, fibrinogen) group and the collagen group. Each group has a distinctive x-ray diffraction pattern as well as physical and chemical properties. The position of the elastic and reticular fibres remained in doubt but recent work (Hall and his colleagues, 1955) suggests that they are essentially members of the collagen group. The constant x-ray diffraction findings, chemical composition, and characteristic structure under the electron microscope, with a constant banding of 640 Ångström units—what Gross has referred to as the finger printing of collagen—has tended to lead to the concept of collagen as a uniform structure of constant chemical composition and configuration. The comparatively slow rate of turnover of labelled glycine in mature rat tail tendon tended to confirm this view.

More recent work has shown that there are definite differences in the collagen [illegible] 1957) and their reaction [illegible] lso a determining factor [illegible] in of young subjects are more vulnerable to the action of collagenase than are corresponding fibrils from the skin of an adult of 24 years or more (Keech, 1955) The author's colleagues have brought forward evidence to suggest that collagen and elastin are members of the same family of proteins and have succeeded in producing a range of morphological products indicative of a possible transformation of collagen into elastic-like material (Hall and his colleagues, 1955). The complete chemical proof of such [illegible] made would suggest that [illegible] ad spectrum of substances [illegible] compound but rather a group of protein fibres [illegible] composition, and with similar. [illegible] with the [illegible] the muco- [illegible] core of collagenous fibrils surrounded by a special sheath [illegible] centage of fatty acids, myristic acid and polysaccharides (Windrum, Kent and Eastoe, 1955).

It will thus be seen that collagen fibrils, and in fact the whole connective tissue system, are not a static tissue but one comprised of elements which are extremely varied in their chemical structure and in their reaction to enzymatic and other agents. Before discussing the changes brought about by disease it is essential to

know the state of the tissue at the time of attack, because the response will be determined as much by the state of the tissue as by the invading organism or its products.

From this brief survey of the connective tissue system it will be seen that there is little ground for calling the diseases under discussion collagen disorders, even if the pathological changes were confined to the connective tissue system.

Steroid therapy and hypersensitivity

Two further arguments have been advanced in favour of retaining the title, namely, their response to steroid therapy and the frequent association of the hypersensitive state with the collagen disorders. The experimental work of Rich of Baltimore (1952) in relation to serum reactions and to sulphonamide sensitivity resulted in the production of pathological changes very similar to those described by Klemperer as being a feature of the collagen diseases. There are recorded cases in which the onset of collagen diseases appeared to follow on drug sensitization, the injection of vaccines, of sera, or after exposure to sunlight and to radiation It has also been claimed that the disorders are much more frequent today than formerly, and that this is the result of the widespread use of sulphonamides and antibiotic preparations. These are difficult views to refute but the increased prevalence could equally well be due to greater awareness of the conditions and to improved diagnostic aids.

The therapeutic role of the steroids has been mainly one of suppression of symptoms in rheumatoid arthritis both for short-term and long-term therapy, if we are to accept the conclusions of the Medical Research Council and Empire Rheumatism Council trials. There is little evidence to suggest that cortisone does much more than bring about relief of symptoms.

RHEUMATOID ARTHRITIS

Clinical diagnosis

Rheumatoid arthritis presents in many forms and the criteria for diagnosis have until recently been mainly clinical The usual onset in some 60 per cent of cases is insidious, beginning with stiffness in the smaller joints of the hands or of the feet, usually symmetrical and worse first thing in the morning, followed by the development of pain and swelling and ultimately deformity. The progression of the arthritic manifestations is often associated with general malaise, anaemia and a raised sedimentation rate Contrary to popular opinion the condition occurs at all ages and the onset is most frequent between the ages of 40 and 50 years In a percentage of cases the clinical manifestations are similar to those described but the onset is acute and fever is prominent, the condition being essentially an acute polyarthritis. In this latter group of cases the differential diagnosis has to be made from other forms of acute polyarthritis, including rheumatic fever.

When the acute form is confined to the wrists and hands and the subject is aged 40 or more years, the possibility of the "arthritis" being due to hypertrophic pulmonary osteoarthropathy should not be overlooked. The author has seen cases of carcinoma of the bronchus present in this way and even admitted to hospital as rheumatoid arthritis.

Differential diagnosis with major joint involvement

Some cases of rheumatoid arthritis present initially with only major joint involvement. Here the differential diagnosis between traumatic arthritis, Reiter's syndrome, gonococcal arthritis (fortunately a rare disease today) and an atypical ankylosing spondylitis, can be difficult. The majority of American authors consider rheumatoid arthritis and ankylosing spondylitis as manifestations of the same disorder but in Great Britain, largely owing to the work of Buckley, they are considered as separate entities. Buckley (1931) clearly demonstrated that Bechterew's disease and the Marie-Strumpell disease were not two disorders but one and the same disorder, now called ankylosing spondylitis. The incidence of peripheral joint involvement in ankylosing spondylitis varies considerably. The majority of authors place it in the range of 5–1 [illegible] indicate the percentage of [illegible] of one of the major joints [illegible] peripheral joint involvement is more frequent in the atypical cases of ankylosing spondylitis. A history of familial incidence of arthritis and the radiological changes in the sacro-iliac joints usually clinch the diagnosis, but when a patient presents with a monarticular arthritis the possibility of ankylosing spondylitis is sometimes overlooked Reiter's syndrome is the most common form of arthritis found in patients attending venereal disease clinics today. The other members of the triad of presenting lesions, conjunctivitis, urethritis, are not always obvious. Iritis and iridocyclitis are stated by Buckley (1948) to be relatively common in ankylosing spondylitis and possibly to be more frequent amongst older patients. A history of eye trouble associated with arthritis therefore requires to be looked into very carefully before making a final diagnosis. The differential diagnosis between the various arthritic conditions has been helped by the development of the differential agglutination test The test, as is seen later, gives a high percentage of positive results in rheumatoid arthritis but only rarely a positive result in cases of ankylosing spondylitis or Reiter's syndrome.

Psoriasis and rheumatoid arthritis

The association of psoriasis and rheumatoid arthritis has long been observed. A recent review by Wright (1956) suggested that although there is an association of the two diseases there is much evidence to suggest the possibility of a distinct clinical entity. The psoriasis is usually well marked and mainly confined to the nails, and the arthritis largely confined to the terminal interphalangeal joints. Furthermore, there is a close correlation between the development of the psoriasis of the nails and the progression of the arthritic changes. Finally, the differential agglutination test was only occasionally positive in cases where the two diseases were associated.

Tendon lesions

Tendon lesions are a very frequent finding in rheumatoid arthritis and their pathology and relationship to the rheumatoid arthritis nodule have been described by Kellgren and Ball (1950) These tendon lesions and the contraction of the fingers that they produce can occasionally be the presenting sign or symptom of rheumatoid arthritis. It is in such instances that the differential diagnosis between nerve

lesions such as ulnar palsy, Dupuytren's contracture, scleroderma and dermatomyositis, may present a problem.

Lesions of the tendon, due to the accumulation of uric acid in gout and muscle disorders, have also to be considered. Thickening of the tendon causing snapping fingers is probably the most common single lesion, but the rheumatoid nodules may occur on several fingers, usually involving the long flexor tendons. Sometimes nodules form on the back of the wrist and may be difficult to distinguish from synovial cysts They are usually composed of granulation tissue and the only treatment is surgical removal Where rheumatoid nodules are the presenting feature surgical treatment should still be undertaken if contractures are developing, but therapy designed towards the management of the general condition of the patient should also be prescribed.

Occasionally hypersensitivity to drugs, and particularly to penicillin, may give rise to an acute polyarthritis which has many features of the early stages of rheumatoid arthritis. There is usually a definite history of chemotherapy and the differential agglutination test is negative.

Diagnostic criteria

Until recently the diagnosis of rheumatoid arthritis had been based almost entirely upon a combination of clinical and clinicopathological data of a non-specific character A Committee of the American Rheumatism Association (Ropes and his colleagues, 1956) have drawn up a list of 11 diagnostic criteria of rheumatoid arthritis and they considered that a 6 weeks' history of symptoms in the presence of 5 of the 11 criteria is adequate for the diagnosis of rheumatoid arthritis in the absence of positive findings of another disease process. The 11 *criteria are as follows*

(1) Morning stiffness

surfaces or in juxta-articular regions

(7)

(8) Positive sheep cell agglutination (Rose and Ragan, or Heller test) *or positive strepto-*

(9)

Rose-Waaler test

Two features of the list should be noted, the absence of reference to the erythrocyte sedimentation rate and the inclusion of the sheep cell agglutination test (D A.T.) or the Rose-Waaler test. The original observations of Waaler were made in 1940 but were not followed up until the publication of Rose and his colleagues in 1948. Since then numerous papers have been published indicating the value of the test in the diagnosis of rheumatoid arthritis. Earlier reports suggested the test was positive in some 50 per cent of cases of rheumatoid arthritis, but a high percentage of positives was also obtained in lupus erythematosus and to a lesser extent in acute rheumatic fever. Modifications in the technique, the use of tanned red cells, latex particles and Bentovite have not only facilitated the procedure, but have tended to increase both the selectivity and the sensitivity of the test.

Rothermich and Philips (1957) using the latex method obtained a positive result in 84 per cent of cases of rheumatoid arthritis The percentage of false positives was low, 26 in 616 of the above series. Eleven of these positives were in cases of non-rheumatic disease, and the remaining 15 in cases that were clinically non-rheumatoid arthritis. There were 2 positives in a series of 17 cases of lupus erythematosus examined, a much lower percentage than in any other reported series. The test appears to be an antigen-antibody reaction. Svartz and Schlossmann (1955) showed that the haemagglutinating factor (for rheumatoid arthritis) was precipitated in the cold but very seldom in other diseases and they considered the test to be specific for rheumatoid arthritis. Svartz (1957) has shown that the factor is associated with the *gamma*-globulin and is a macro-globulin but has not yet succeeded in separating the factor. The demonstration of an inhibitor of the [illegible] factor by Ziff and his colleagues (1954) as well as by Heller and [illegible] est. It has already proved [illegible] e light upon the aetiology of rheumatoid arthritis

The test has, however, certain interesting clinical associations It is rarely positive during the first 3 months of the disease and is often not positive until 6 months after the initial symptoms have appeared. In some patients the test is variable, positive on one occasion, negative on another and *vice versa*. The significance of this change is not understood, especially as in many long-standing cases of rheumatoid arthritis the test is positive *Furthermore, positivity seems to bear* no close correlation to clinical severity or to the erythrocyte sedimentation rate. Kellgren and Lawrence *(1956) used the test in* their survey of the incidence of [illegible]

Radiological diagnosis

Experience *resulting from the population* surveys and the *therapeutic trials* arranged by the Empire Rheumatism Council have assisted in clarifying opinion on the radiological changes in rheumatoid arthritis. The terminal interphalangeal joint has been found to be useless as a basis of assessment, and the changes in the wrist joint proved to be ones most likely to lead to disagreement and misinterpretation. At the Ninth International *Congress on Rheumatic Diseases*, held in Toronto in June, 1957 (Kellgren and Lawrence, 1957), experts from different coun-

tries were asked to grade films in relation to four factors, osteoporosis, erosions, rheumatoid arthritis and osteoarthritis. There was considerable unanimity for the severe case of rheumatoid arthritis, but in the moderate degrees of involvement the differences in interpretation were appreciable. The greatest discrepancy between observers was found in the assessment of erosions. The value of the report lies in the indication of a growing agreement as to the essential radiological diagnostic criteria. Intra-articular narrowing, of less than one millimetre, has been shown to be significant in the Empire Rheumatism Council trials and was not listed as a specific test at Toronto but was included for the overall assessment.

LUPUS ERYTHEMATOSUS

Lupus erythematosus is perhaps more familiar to the dermatologist than to the general physician, although as long ago as 1872 Kaposi described the acute form of the disease and the varied clinical manifestations. The localized discoid tumours of the skin are considered by many dermatologists to be a distinct disorder and not a localized manifestation of a more general disease. Gold, in his review of this disorder, and also most of the American authorities, do consider that there is no clear-cut distinction between the localized and generalized forms of the disease. For practical purposes the classification of O'Leary into chronic discoid, generalized discoid, subacute and acute disseminated forms of lupus erythematosus is generally used as a working basis. The skin lesions may be found in all parts of the body but are very common on the face, particularly round the eyes. They usually appear in the disseminated forms of the disease as erythematous macules on the bridge of the nose which tend to coalesce and form the so-called butterfly erythema Erythematous macules in the fingers are also frequently present in the acute disseminated forms In addition to the rashes, arthralgias, arthritis, leucopenia, visceral involvement, pericarditis, pleurisy, anaemia, and renal damage are prominent features in the disseminated forms of lupus erythematosus. The condition also differs from the other "collagen diseases" in having a very high incidence amongst women. Some 80–90 per cent of the cases occur in women and particularly in the age group 20–40 years The renal changes are also important When atypical rheumatoid arthritis occurs in a young woman with anaemia, leucopenia, and the presence of albumin or red cells in the urine, a diagnosis of lupus erythematosus should be suspected. Great prominence was given to the involvement of the heart following the report of Libman and Sacks (1924) of 4 cases with vegetations on the heart valves. Certainly lupus erythematosus has to be considered in the differential diagnosis of bacterial endocarditis and in some cases of rheumatic fever, but most of the clinicopathological reports would suggest that involvement of the heart valves is not a common feature of disseminated lupus erythematosus Far more important is the development of acute haemolytic anaemia or, in a supposed case of rheumatoid arthritis, of pleurisy, pericarditis or visceral involvement

The L.E. cell

The diagnosis of lupus erythematosus rested in the past very largely on the varied clinical presentation associated with the development of a rash until the discovery in 1948 by Hargreaves, Richmond and Morton, of the Mayo Clinic, of the so-called L E cells These cells were first discovered in the bone marrow, but now numerous

techniques have been devised for demonstrating their presence in the peripheral blood In the L.E. cell, a leucocyte, is a large, homogeneous mass now thought to be ingested nuclear material which stains with Feulgen's solution, a reaction which is indicative of the presence of desoxyribose nucleic acid. The test is an *in vitro* and not *in vivo* test, and requires three constituents: (1) a source of nuclear protein, (2) a factor in the serum or plasma of a patient suffering from lupus erythematosus, and (3) active phagocytes. It is usual for the blood to be incubated, but sometimes fresh blood can be used and sometimes heparinized blood. For a discussion of the relative merits of the different techniques, it is necessary to consult the respective authorities. The greatest difficulty in the interpretation of results has been over the criteria that constitute an L.E. cell. Numerous errors have been made in the past, particularly mistaking tart cells, erythrophagocytosis, platelet aggregations and even amyloid bodies as L.E. cells.

Systemic lupus erythematosus is of most concern to the surgeon when it presents as an atypical arthritis, pyrexia of unknown origin, haemolytic anaemia, Raynaud's phenomenon, or as an unexplained albuminuria. The discovery of the L.E. cells has raised almost as many problems as it has solved and more particularly the problem as to the precise significance of the finding. Harvey and his colleagues (1954), in a review of the condition, fully discussed the specificity of the L.E. cell. Criteria for the cells are now generally accepted and it is usually recommended that the finding of 4 cells on a slide on at least two occasions is a minimum requirement for considering the test as positive. The L E. cells have been reported in numerous conditions (Bateman, Malin and Meynell, 1958), although the most important consideration is the significance of their occurrence in rheumatoid arthritis. The Dutch workers, Kievits and his colleagues (1956), found L.E. cells in 17 per cent of 618 cases of rheumatoid arthritis. The group with L.E. cells showed a higher percentage of splenomegaly, diseases of the lower respiratory tract, abnormal urinary sediment, anaemia, and false positive tests for syphilis, but the authors could not find any evidence that the patients [illegible] picture different from those cases of rheuma[illegible] were observed. In another series (Bateman, M[illegible] were found in 28 cases of rheumatoid arthritis. Systemic lesions in keeping with a diagnosis of lupus erythematosus occurred in 15, but in 13 arthritis was the only symptom. In one fatal case autopsy revealed no characteristic lesions of systemic lupus erythematosus. It is conceivable that these cases in the above series might have had both lupus erythematosus and rheumatoid arthritis. The similar association of a relatively high proportion of positive D.A.T. tests in lupus erythematosus might be regarded as further evidence of a tendency to association of the two diseases or to some common pathological process, that is, something in the serum capable of destroying desoxyribose nucleic acid.

The discovery of the L.E. cell has provided a valuable diagnostic aid and the evidence would suggest that its finding has a considerable degree of specificity.

It is interesting to note that following therapy with cortisone or cortisone-like substances and with nitrogen mustard L.E. cells have, in some cases, disappeared and in others been reduced to a very low count. Also, exacerbations of the disease are frequently associated with an increased prevalence of L.E. cells in the peripheral blood. The fact that cortisone and similar chemical compounds can lead to a

disappearance of L.E. cells does lend hope to the possibility that these compounds may have a curative effect and not merely bring about a suppression of symptoms.

SCLERODERMA

Clinical picture

Scleroderma may occur either in localized areas of the skin, when it is often referred to as morphoea, or as a generalized disease involving the hands, arms and face, although all parts of the body and all organs may be involved Considerable *disagreement still exists amongst dermatologists and other clinicians as to whether* these differing clinical entities are part of one and the same disease process. The frequent association of Raynaud's phenomenon with scleroderma of the hands has led many dermatologists to the view that more than one disease process is involved, and they do not consider that the localized form of the disease in the hands—acrosclerosis—is the same condition as the more generalized form of diffuse and progressive scleroderma (O'Leary and Waisman, 1940).

When the condition is confined to the hands and forearms and is associated with vascular disturbances, the relationship of scleroderma to Raynaud's disease is difficult to determine. Sometimes the vascular disturbances are observed before the dermatological signs are evident and then the differential diagnosis is even more difficult. Both conditions occur more frequently in women than in men and the onset is usually during the second decade of life. Vasodilatation is less readily obtained after sympathetic block in scleroderma than in Raynaud's disease. There is much evidence to suggest that the circulatory changes are secondary to pressure effects of the subcutaneous tissues on the blood vessels in scleroderma Gangrene and calcification are extremely rare in Raynaud's disease and if found are more suggestive of acrosclerosis or scleroderma The increasing stiffness and tightness of the skin and tissues leads, in the case of the hands, to the swelling of the tissues and to the development of deformity In addition to the hands other regions of the skin, particularly the face, may be involved and give rise to a mottled cadaverous appearance The skin of the trunk may also be involved, particularly round the neck and on the anterior aspects of the chest The condition may remain localized or may become steadily progressive. In the latter case progress of the disease is usually accompanied by general symptoms such as weakness, loss of weight, and symptoms arising from visceral involvement such as dysphagia, dyspnoea and cyanosis. The dysphagia was thought to be due to a sclerodermatous infiltration of the lower end of the oesophagus Thickening of the subcutaneous tissue, proliferation of granulation tissue, and a well-marked oesophagitis have been reported, but a more frequent finding is a dyskinesia of the oesophagopharyngeal junction; in other words, a failure of peristaltic movement to cross the junction.

Aetiology

The aetiology of scleroderma remains obscure Normal histological investigations have revealed a tendency to swelling and fragmentation of the collagenous fibres, atrophy of the sebaceous glands and hair follicles. Electron-microscope studies have not revealed any gross changes in the appearance of the collagen fibrils nor has any striking difference been observed in the response of the fibrils to changes in *p*H or to enzyme action

Hall and his colleagues (1958) recently reported the presence of cellulose in skin from a case of scleroderma. Further work has revealed the presence of cellulose in normal human skin, but it was the large amounts in a case of scleroderma that first drew attention to the presence of cellulose in human tissues. Cellulose had previously been observed in one animal species, namely, the sea squirt, which is usually considered to be a degenerate form of animal life. It is conceivable that a change in the enzymatic components of connective tissue could lead to the production of cellulose from glucose. The presence of considerable quantities of cellulose in the dermis could explain the more solid nature of the skin and, by its pressure effect upon the blood vessels, account for the vascular phenomenon.

POLYARTERITIS OR PERIARTERITIS NODOSA

Periarteritis nodosa was first described by Kussmaul and Maier (1868) Many authorities, following on the work of Rich (1952), have suggested that this disorder is a manifestation of the hypersensitive state, but a careful analysis of the reported cases does not provide convincing evidence that the disorder is invariably related to drug administration, to drug hypersensitivity or to repeated courses of drugs, although a number of cases have been reported which suggest such a relationship. In a recent analysis of the disorder by Rose and Spencer (1957), two interesting clinicopathological observations have been made. It has long been known that the condition may present not only with fever and rashes of all kinds, scarlatinal, form, urticarial, bullous and erythema nodosum-like nodules, but there may also be widespread evidence of involvement of the muscles, myalgic pains, lung lesions, peripheral neuritis and renal damage. In the analysis of Rose and Spencer, the cases with lung involvement usually took the form of asthma, bronchitis or pneumonia, and there was a high incidence of eosinophilia. The clinical course was slightly different from that of the diffuse polyarteritis. The respiratory infection might precede the onset of diffuse polyarteritis by as much as 8 years, although in the majority of cases the interval was less than 2 years. The onset of the polyarteritis was usually abrupt, often occurring during an exacerbation of respiratory illness, and was followed by a rapid deterioration in the clinical condition of the patient.

Muscle biopsy, often a blind biopsy taken from the scapular region or from the thigh, has been employed in an attempt to establish a diagnosis. From time to time the typical periarterial inflammatory changes have been observed in material from a blind biopsy, but a negative report by no means excludes the diagnosis.

In unexplained cases of peripheral neuritis, diarrhoea or hypertension, the possibility of periarteritis nodosa has to be considered It is interesting to note that Rose and Spencer (1957) found hypertension to be a late development in periarteritis nodosa. It was rarely found in the acute stage of the disease and they suggested that the hypertension resulted from the healed sclerosing lesions of the kidney.

Temporal arteritis

Horton's disease or temporal arteritis has a similar histological appearance in the affected vessels but it is a distinct clinical entity. Temporal pain or headache associated with tortuous and tender temporal arteries, and occasionally blindness, are the common presenting features. Section of the affected area of the artery has

been recommended for treatment The condition occurs most frequently during the second half of life and is not associated with generalized disease of the arteries.

DERMATOMYOSITIS

This disorder is the rarest of the so-called collagen diseases and a recent review by Walton and Adams (1958) provides an excellent account of the reported cases. The disease may run an acute, subacute, or chronic course and is characterized by dermatitis, oedema, and muscular weakness. It tends to be a progressive lesion, usually manifesting itself as a sclerosing lesion round the eyes characterized by its peculiar colour due to the presence of telangiectasia. In addition to the skin lesions of the face, skin lesions are common around the joints and on the trunk, particularly the v-shaped area of the neck, and the early involvement of the posterior aspects of the neck sometimes helps to differentiate the condition from lupus erythematosus Exposure to sunlight, as in lupus erythematosus, tends to aggravate the dermal lesions. Skin lesions, however, are not always present, and even when present may not be sufficiently prominent to bring the patient to the doctor. In many cases it is the muscular pain or periodic swelling of the tissues which makes the patient seek advice The periodic swelling, due to oedema, may cause an initial diagnosis of angioneurotic oedema to be made In all the cases reported by Walton and Adams (1958) muscular weakness and wasting was a prominent feature In fact, so prominent were these that diagnoses such as progressive muscular atrophy, myasthenia gravis, and muscular atrophy had been made initially in some of the cases seen by them. These authors considered that in any unusual case of muscular wasting or excessive fatigability, dermatomyositis must be considered in the differential diagnosis. They also stressed the occurrence of dermatomyositis without involvement of the skin Raynaud's phenomenon has been described in some of the reported cases, but this must be considered a very unusual feature and it is possible that there is an association of diseases. The disorder may develop at any age and has a slightly higher incidence in females. The aetiology of the condition remains unknown but other tissues, particularly the mucous membranes, are liable to be involved so that the disease is not confined to the connective tissue system.

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VENOUS ULCERS OF THE LEG

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INTRODUCTION

Ulcers of the leg are very common. Until recently they have also been ill-understood In fact, the differential diagnosis of these lesions offers much scope for clinical acumen, and in the Table below is a scheme of the main headings for differential diagnosis.

TABLE OF HEADINGS FOR DIFFERENTIAL DIAGNOSIS OF VENOUS AND NON-VENOUS ULCERS

VENOUS ULCERS

1 Due to valvular incompetence or destruction in one or more of the following systems
  - The long saphenous system
  - The short saphenous system
  - The direct ankle perforating veins

The specific sign of all venous ulcers is the ankle flare

2. Due to pure gravitational venous stasis—the veins being dilated—but no valvular incom-

The specific clinical test for all venous ulcers is that ...ing if ...vated

the limb

3

people are often due to congenital arteriovenous fistulas in the limb

NON-VENOUS ULCERS

1. Those due primarily to arterial pathology. These include
   (i)
   (ii)
   (iii)

2. Ulcers occurring on an area of "poor skin"

3. Ulcers due to specific infections
   - Syphilitic ulcers
   - Tuberculous ulcers

4. Neoplastic ulcers / Primary
   \ Secondary neoplastic change in chronic venous ulcers (Marjolin's ulcer)
5. Ulcers associated with gravitational purpura
6. *Meleney's ulcers* or progressive bacterial gangrene of the skin
7. Ulcers occurring as common complications of certain general diseases
   Acholuric jaundice, ulcerative colitis, rheumatoid arthritis and Cushing's syndrome are four diseases which appear to carry ulceration of the leg as a specific complication

In this article the pathology and treatment of those ulcers classified as "venous ulcers" due to valvular incompetence or destruction are dealt with in detail; these ulcers form the bulk of those seen commonly today.

ANATOMY

A knowledge of the anatomy of the venous system of the leg, and the amazing physiology of venous return, is necessary before the pathology and treatment of these lesions can be appreciated.

The leg may be regarded as a muscular tube with the main veins running up the centre. These muscles are enveloped in a strong, relatively rigid, fascia Outside the fascia is the envelope of skin and subcutaneous tissue.

The soleus is the largest and most powerful muscle of the leg; within it there is a series of large valveless venous sinuses, and it is the *only* muscle in the leg with this arrangement. These sinuses drain by a series of segmentally arranged veins into the posterior tibial and the upper part of the peroneal veins.

The path of discharge of venous blood from the soleus is as follows: venous sinuses→segmental veins→posterior tibial and peroneal→popliteal→femoral.

The envelope of skin and subcutaneous tissue has its own venous system consisting of two long collecting trunks (the long and short saphenous veins), which end at the groin and popliteal fossa respectively by perforating the deep fascia and entering the main deep vein There are also dotted about the limb a number of smaller perforating veins.

These perforating veins are of two sorts *direct* and *indirect*.

The *direct* perforating veins are few, fairly large, and in definite anatomical positions, and perforate the deep fascia to enter directly a main deep vein. The *indirect* perforating veins are more numerous, are very small, and are dotted about over the big muscle bellies in the leg; they anastomose with small intramuscular veins.

One of the most significant points in the pathology of ankle ulceration is the anatomical fact that there is relatively little in the way of muscle bellies in the ankle region and thus the numerous small indirect perforating veins are absent in this part of the limb, the whole venous drainage being handled by a few large direct ankle perforating veins.

Long saphenous vein

The anatomy of the long saphenous vein, its branches and the arrangement of the direct ankle perforating veins on the inner side of the limb is shown in Fig. 1.

Looking at this diagram there are three points worthy of comment. The first is that there are usually three direct perforating veins in the position shown. However, there is considerable variation in their relative size. When the middle one is large, then the upper one is often very small or absent. When the upper one is large then the middle one may be small or absent. Occasionally they are of the same size; and occasionally there may be more than three

The second point is that the upper and middle perforating veins, after penetrating the fascia, join the posterior tibial veins at the precise point where a segmental vein draining soleus also joins it Thus clot spreading down from the soleus spreads as far as the valve in the perforating vein at this point, and then upwards along the posterior tibial vein. This is the method whereby the valve in the perforating vein is destroyed by a deep thrombosis (*see* Fig 7). The third or lowest ankle perforating vein just below and behind the internal malleolus has not got this typical anatomical arrangement, so its valve usually escapes, and it is very rarely involved in post-thrombotic perforator incompetence (Fig. 7). The middle and upper perforators are the significant ones

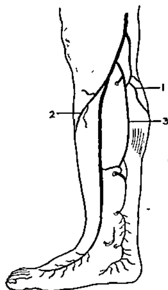


Fig. 1.—The anatomy of the long saphenous vein and the direct ankle perforating veins on the inner aspect of the leg The branch labelled 3 is the large constant posterior arch vein.

The third point to notice is the way the great saphenous vein gives rise to a large constant posterior arch branch at or just below knee level. This was first correctly depicted by Leonardo da Vinci It arches down to end by forming a series of

arcades with the direct ankle perforating veins, from which arise the delicate venules which drain the ankle skin. The bottom of this arcade then breaks up into a number of branches which disappear into the heel pad. These latter branches, at the bottom of the posterior arch vein and the arcades joining the perforating veins, are the ones which become so dilated in venous incompetence and are seen clinically as the ankle flare (Fig. 2).

Short saphenous vein

The corresponding anatomy of the short saphenous vein, and the lateral direct perforating vein is shown in Fig. 3. The anatomical vagaries of the short saphenous



FIG. 2—This picture shows the prominent ankle flare in a case of ankle perforator incompetence.

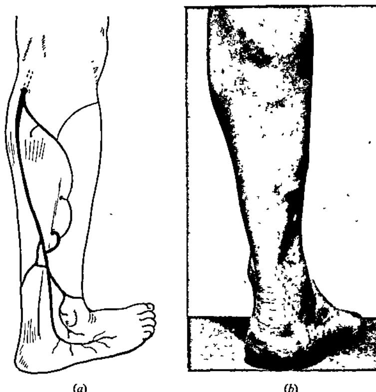
vein have been fully described elsewhere (Dodd and Cockett, 1956) but the two points worthy of notice are: (1) the way the lateral direct perforating vein nearly always enters the short saphenous vein direct (in marked contrast to the medial ankle perforators), and (2) the way the short saphenous vein breaks up rapidly into a sheaf of terminal branches just below and behind the external malleolus.

With every direct perforating vein there is also a perforating artery of fair size.

PHYSIOLOGY OF VENOUS RETURN FROM THE LEG

It is essential to understand the normal physiology of venous return from the leg *before abnormal or pathological physiology* which results in varicose veins and venous ulcers can be appreciated.

When a man is lying flat with his legs still and at approximately the same level as the heart, the venous return flows towards the heart impelled by the arterial *vis a tergo*, and all veins superficial and deep play their part As soon as the limbs are raised even slightly above heart level, the force of gravity is added to the



(*a*) (*b*)

FIG 3 —(*a*) The usual anatomy of the short saphenous vein, with its accompanying lateral direct perforating vein, (*b*) shows a case of fairly advanced short saphenous incompetence, with early ulceration over the lateral malleolus, and a prominent bulge over the lateral direct perforating vein.

vis a tergo in impelling the venous blood back to the heart, and under this condition the circulation time and speed of venous return in the lower limb is at its fastest and most efficient. (Payling Wright, 1952)

In the erect position muscular movement is the main factor which is responsible for venous return. The powerful soleus muscle, and the other calf muscles, ensheathed in the inelastic deep fascia form a very efficient pump. Every contraction of this pump drives the blood inwards towards the main deep veins and upwards towards the heart—the direction of flow being governed by the arrangement of the valves in the veins. The main deep veins of the leg and foot are very profusely valved (Dodd and Cockett, 1956).

The venous return of the skin and subcutaneous tissues in the erect exercising limb is almost entirely inwards via the perforating veins and upwards in the deep veins The long collecting veins (long and short saphenous) play little part in the

return of blood from the skin and subcutaneous tissues of the erect exercising limb. All the perforating veins, direct and indirect, are provided with a valve or valves which are so arranged to allow this inward flow of venous blood towards the deep veins, and prevent reflux outwards. The efficiency with which the subcutaneous veins are emptied by the diastolic inflow into the calf pump is shown by a study of the behaviour of the venous pressures in the deep and superficial veins. At rest in the erect position the pressure in the deep and superficial veins at any point in the limb is the same and equal to the height of a column of blood between that point and the heart. When the muscles are exercised, however, the pressure in the deep veins remains high with violent fluctuations, but the pressure in the superficial veins rapidly falls away to almost nil as they are emptied into the calf pump.

Now the essential basic fault in all forms of varicose veins and venous ulcers is that this fall of superficial venous pressure on exercise does not occur. The pressure in the superficial veins remains high on exercise, and the blood is not cleared efficiently into the calf pump via the perforating veins. The reason for this is a failure or destruction of one or more of the strategic valves guarding the mouth of one of the perforating veins, which then allows a reflux of blood at high pressure into the superficial tissues. These valvular failures allow, as it were, a "leak" of high pressure blood into the superficial tissues.

Thus a leak occasioned by failure of the highest saphenous valve at the groin will allow steady reflux out and down the great saphenous system.

A leak occasioned by failure of the highest short saphenous valve, where it joins the popliteal vein, will allow a reflux down, and gradual distension of this vein.

A leak occasioned by destruction or failure of the valve in one or more of the direct ankle perforating veins will allow high pressure reflux into the subcutaneous tissues of the ankle at every contraction of the muscles.

Moreover, the leak high in the limb will be at a lower pressure than a leak at the bottom of the limb (because the pressure in the deep veins is higher at the ankle and accentuated by calf pump exercise).

PATHOLOGY

The way in which a high venous pressure is transmitted to the ankle area via either the posterior arch branch of the great saphenous or the short saphenous or one or more of the direct ankle perforating veins may now be appreciated.

The most obvious effect of this steady high venous pressure is to cause the subcutaneous veins and venules of the ankle area to dilate.

One of the earliest clinical signs of this venous dilatation is the appearance of the flare of veins disappearing into the heel pad. This represents the lower end of the venous arch connecting the ankle perforating veins and constitutes the specific sign of a venous ulcer—the ankle flare (*see* Figs. 2 and 3).

The speed and degree of this venous and venular dilatation round the ankle depends on a number of factors. The most important of these are as follows:

(1) The level in the limb of the venous "leak". For example, long saphenous incompetence might take 10 years to produce the same amount of venous dilatation round the ankle which could be produced by an ankle perforator leak in 2 years.

(2) The amount and type of work in the upright position that the patient has to do, and the amount of rest that can be taken.

(3) Individual variation. This is quite important because there is no doubt that different people's veins and tissues react to venous stress differently.

However, once a certain amount of venous dilatation has occurred round the ankle the stage is set for an ulcer The actual ulcer may be initiated by trauma, rupture of a vein, or infection in a patch of eczema.

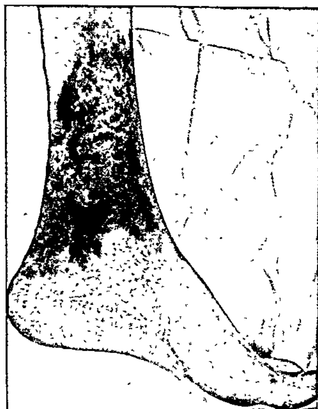
It is important to realize that most ulcers occur over the area of maximum venous dilatation in the ankle, and they can usually be felt to be sitting on a "bog" of dilated veins if they are palpated gently with the patient in the erect position. Thus venous ulcers are "hyperaemic" lesions They have too much blood in them at too high a pressure.

Moreover, as time goes on and the lesion is untreated this venous and venular dilatation becomes so excessive that the whole area becomes rather like a large haemangioma—a mass of tiny, tortuous, dilated blood vessels embedded in fibrous tissue. This haemangioma-like state of the ankle tissues is shown strikingly by the venogram in Fig 4.

Once this "haemangiomatous state" has established itself over many years it tends to become a self-perpetuating lesion. The perforating arteries going to the area become large and tortuous, and it is interesting that this venous network

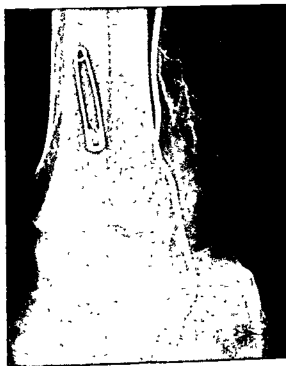


FIG 4—The vascularity of an ulcer. The venogram of a 10-year-old post-thrombotic ulcer over the internal malleolus. The top arrow points to the incompetent perforating vein, and the lower arrow to the site of the ulcer Note the way the subcutaneous tissues *below* (but not above) the perforating vein are filled with



(*a*)

FIG. 5.—(*a*) A post-thrombotic, localized ulcer which had been present for many years; (*b*) Arteriogram showing the enlarged lateral branches of the posterior tibial artery going off to the ulcer area; and (*c*) A close-up arteriogram of the ulcer area, showing the "haemangioma-like lesion". The flow is so fast through the area that the contrast material is already filling a vein giving an appearance not unlike an arteriovenous communication.



(*b*)



(*c*)

can then be outlined well by an arteriogram—even occasionally giving the appearance of arteriovenous anastomoses (Fig. 5).

Anything which further aggravates the vascularity of the area such as inflammation (from chronic infection round an ulcer, or round an area of fat necrosis) or an ill-advised sympathectomy, will help to perpetuate and worsen the whole lesion. This concept of the gradual establishment of a local very vascular lesion is important when we come to consider surgical treatment, for when this lesion has

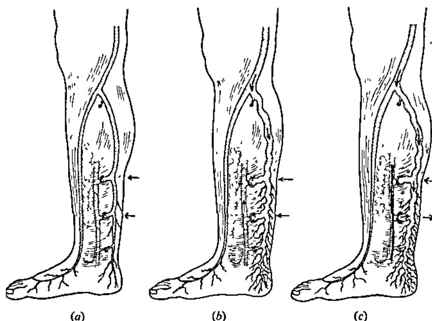


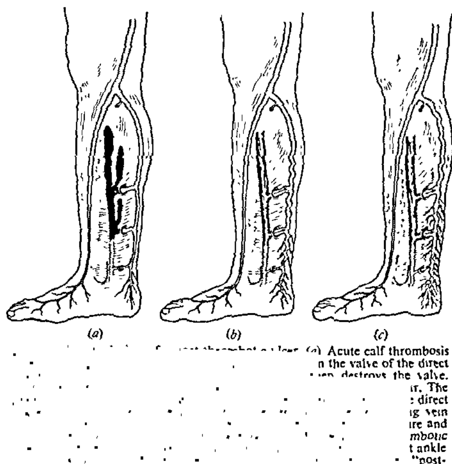
Fig 6 —The evolution of a venous ulcer with varicose veins of the great

intractable venous ulceration.

established itself at the ankle after many years, the mere cutting off of the incompetent veins which originally caused it will have little effect. The lesion itself must then be excised *in toto* The best time for surgery of the veins is before this lesion has established itself, or in its very early stages

In Fig 6 is shown the gradual evolution of a venous ulcer due to an incompetent great saphenous system, and the way in which the whole condition of the ankle is aggravated considerably if in addition the valve of an ankle perforator becomes incompetent. This may occur for no very obvious reason, as a result of thrombosis spreading from superficial veins inwards, or as a result of calf thrombosis.

One of the most important effects of deep calf thrombosis is the destruction of the valves in the direct ankle perforating veins. The evolution of a post-thrombotic ulcer is shown in diagrammatic form in Fig. 7. In post-thrombotic cases the actual ulceration and destruction of the ankle skin is often caused by the incompetent ankle perforating veins alone. Post-thrombotic valve destruction in the deep veins themselves may cause a variety of other symptoms in the limb, but is not



[illegible] (a) Acute calf thrombosis [illegible] n the valve of the direct [illegible] destroys the valve. [illegible] The [illegible] direct [illegible] vein [illegible] and [illegible] mbotic [illegible] t ankle [illegible] "post- [illegible]

directly contributory to the ulcer. It follows that operative treatment of post-thrombotic ulcers—by finding and tying the ankle perforating veins—is an effective and logical treatment.

The main territory of venous drainage of the short saphenous vein is the skin round the lateral malleolus and it is here that ulcers and eczema due to valvular failure of the short saphenous and its accompanying perforating vein tend to occur. It must not be forgotten, however, that short saphenous incompetence may occur as a sequela of deep thrombosis, and the combination of short saphenous incompetence with internal-ankle perforator incompetence is not unusual and may produce severe pain, swelling, and ulceration in the usual site on the inner aspect of the ankle.

Various effects of venous hypertension and vein dilatation round the ankle

The rapidly increasing venous hypertension and dilatation round the ankle produces a variety of effects:

(1) In a fat female leg a brawny, painful, red indurated plaque may appear. This is an area of diffuse fat necrosis. This diffuse area of fat necrosis may rapidly break down and ulcerate, in which case an extremely painful ulcer is produced. Usually, however, after passing through a stage of painful sterile inflammation the necrotic fat is gradually absorbed and the whole area contracts down into a diffuse fibrous vascular plaque.

(2) Extravasation of blood and the deposition of brown haemosiderin pigment occasionally occurs to a marked degree.

(3) Contracture of the tendo Achillis. In the very painful early stage of some ulcers the foot tends to be held in the position of extreme equinus. If this is not corrected by physiotherapy and exercise in the early stages a permanent shortening occurs, leading to marked equinus deformity This in turn leads to a whole series of secondary deformities in the foot, and the patient may end up with a pes cavus and numerous callosities. This condition is often seen in old untreated ulcer patients

PRINCIPLES OF TREATMENT

The basic pathology of all venous lesions round the ankle is an abnormal venous hypertension in the subcutaneous tissues, which persists, instead of decreasing, on exercising the leg

Any treatment which reduces or prevents this abnormal hypertension will be successful in curing a venous ulcer, or any venous lesion or symptom.

In practice this can be achieved in three ways.

Rest in bed with the feet just higher than the heart

By this simple means the venous pressure, deep and superficial, in the legs is reduced to zero, any symptom (pain, aching, eczema, irritation) of venous origin will rapidly recede and venous ulcers start to heal Local applications have little affect, and it may be best to leave the ulcer uncovered. Unfortunately, when the patient gets up again, the symptoms return, and ulcers tend to recur.

Application of an evenly distributed external pressure to the whole ankle area

For this various sorts of elastic bandage are used It is the most practical and generally useful technique for healing and controlling venous ulcers, and has the great advantage that a patient may continue at work during treatment. Again its main disadvantage is that once an ulcer has been healed by this means it tends to recur when the support is discontinued

Surgery

Following accurate diagnosis of the site of the high-pressure venous "leak" from the deep veins, the surgeon deals with this leak or leaks by appropriately placed flush division and ligature of the perforating veins at fault, and removal of as much as possible of the dilated superficial veins resulting from this high pressure leak

Combined methods

In practice the best results are obtained by a combination of these methods For instance all three methods may be used in the cure of a long-standing venous ulcer.

When first seen with a large ulcer the patient may be instructed in the art of elastic bandaging. This method, while the patient is still at work, may reduce the ulcer to a small size or actually heal it. The patient is then admitted to hospital. After a few days or a week or so at rest with the foot of the bed elevated, the ulcer finally heals and all oedema and induration subside. The leg is then in excellent condition for the definitive operation on the veins which will finally cure the ulcer.

Support and bandaging will again be required in the post-operative phase until healing is solid and complete.

Thus all three methods play their part in the successful management of venous lesions.

The technique of the last two methods is considered in detail.

PRESSURE BANDAGING

The techniques of so-called occlusive bandaging are multitudinous, and the very multiplicity tends to obscure the simple principles involved. The essential *sine qua non* for control and healing of a venous ulcer is the even application of an external elastic bandage over the whole area of the foot, heel, ankle and leg. The bandage must be strong enough to overcome the high venous pressures involved (that is, over 100 millimetres of mercury). This external pressure can be accentuated where it is most wanted, that is, actually over the ulcer, by the inclusion of a small felt pad covering the ulcer, under the bandage.

Neither crêpe bandages nor elastic stockings have the necessary elastic strength to maintain adequate external pressure over the ankle region for an adequate period of time and are therefore usually inadequate actually to heal a severe venous ulcer. After it has healed a good elastic stocking may help to maintain healing for a long time.

From the point of view of leg bandaging, patients fall into two distinct classes. (1) There are those (reasonably intelligent) who can be taught the technique of pressure bandaging with the dry webbing elastic bandage. (2) There are those (unintelligent or stupid) who cannot be taught how to use this simple manoeuvre consistently. For this latter type of patient the occlusive pressure bandaging method with Elastoplast is preferred.

Before describing these two techniques certain general points must be stressed.

State of the skin

First, the skin around an ulcer and indeed in many legs with severe venous disease is extremely sensitive to local applications. It is a sad fact that many of the worst varicose eczemas and bad skins are due to the sensitization reaction to the numerous local ointments and applications which have been applied. The antibiotic creams of all types, flavine preparations, sulphonamide ointments, Elastoplast, tulle

gras and eusol are all particularly prone to excite widespread and explosive weeping eczema in such cases. Moreover, the eczema once started in the leg may spread to the rest of the body and the last state of such a patient may be worse than the first. These widespread eczemas, once started, are extremely difficult to control. The best thing is not to start them, and to treat by applying either a simple dry dressing to the ulcer, first moistening the skin around with olive oil to prevent sticking, or very "runny" zinc cream (zinc oxide in castor oil). We have found this local application, which prevents dressings sticking, to be consistently innocuous. It cannot be too strongly emphasized that it is the elastic pressure of the bandage which heals the ulcer—not the local application.

Bandaging technique

The second point is that in both methods of pressure bandaging to be illustrated it is the immaculate technique of applying the bandage smoothly round the ankle and lower leg to get firm even pressure over the whole area which counts Handing an elastic bandage to a patient with an ulcer and telling him or her to put it on is no good Trained nurses or assistants (or even occasionally the doctor himself) must be prepared to spend time putting the bandage on correctly or teaching the patient how to do this

Occlusive pressure bandaging method

In this method, suitable for class 2 patients, a sticky bandage (either ordinary Elastoplast or diachylon plaster) is applied evenly and firmly from toes to just below the knee. It must be put on over stockinette or Tubagauz. On no account must it be applied to the bare skin (otherwise a high proportion of severe sensitivity reactions will follow).

The bandage is left on for a period of 10–14 days, when it is taken off and renewed for a further fortnight This is continued until the ulcer has healed This method—championed originally by A. Dickson Wright—is simple and effective.

Intermittent dry bandaging method

In this case the patient is taught how to put on the webbing elastic bandage, which is a dry bandage, over the felt pad

The patient applies the bandage first thing in the morning, and takes it off at night. He sleeps with the foot of the bed raised and with a light crêpe bandage only on his leg This method has two advantages. First, the leg can be cleaned or bathed when the bandage is off. Secondly, the pressure is kept at the optimum strength by the fact that the patient puts it on fresh every day With a little trouble this bandaging technique can be mastered by most patients, and the author has found this method to be the quickest and best for healing ulcers, and for the routine after-care of the various vein operations.

OPERATIVE TREATMENT

Any patient whose ulcer is due to incompetent veins of the long saphenous system, short saphenous system, or ankle perforating veins can be greatly improved, and in most cases permanently cured by adequate and radical surgery.

Most patients under the age of 60 years who wish to lead an active untrammelled life prefer surgery, as this offers them the chance of freedom from continuous wearing of elastic bandages or other support. Over the age of 60 years, most patients prefer their bandages as against the unknown hazards of an operation, and this, in the author's view, is an eminently reasonable attitude. The operations are not hazardous if properly carried out and with the proper after-treatment, and can safely be offered to patients in any age group who wish to be rid of their ulcer. These operations are unfortunately time consuming from the surgeon's point of view. They should not be undertaken unless the surgeon is prepared to give adequate time at operation, and adequate time for the after-care for the patient.

The following is the essential general scheme of surgical management of the ulcerated leg.

(1) A preliminary period of pressure bandaging or rest in bed with the feet elevated, or both, to heal or nearly heal the ulcer. The patient should not be brought to operation until the ulcer is healed or in the healing phase, until all infection and oedema are controlled.

(2) The planned operation means a careful assessment of which systems of veins need operating on (long saphenous, short saphenous, ankle perforating veins or all three together); a decision as to whether the ulcer has to be excised and grafted, and whether an extrafascial or subfascial operation on the perforating veins is needed. The operation must then be carried out with full attention to detail, and adequate time set aside for it.

(3) The after-care is essential. After an exploration of the ankle perforating veins, the patient must spend at least 7–10 days in hospital. During this time the foot of the bed is elevated and he is not allowed to sit upright (except for meals). Active leg exercises in bed are instituted, and later graduated daily walking periods are started with the ankles firmly pressure bandaged. The patient is taught how to apply the pressure bandage himself and when he is discharged from hospital should be an expert, and must wear his pressure bandages during the day while he is walking. Activity is encouraged These pressure bandages are a most essential part of the post-operative treatment and should not be discarded until seen by the surgeon at the follow-up clinic 1, 2, or 3 months after operation, depending on the extent of the operation.

Operative technique

Most venous ulcers require an exploration and division of the incompetent internal ankle perforating veins for their permanent cure This involves an incision and operating in the immediate vicinity of the ulcer. Hence the great importance of the pre-operative treatment to control infection and oedema.

Exploration of the ankle perforating veins will in most cases have to be combined with either a flush sapheno-femoral ligation and strip of the great saphenous vein, or flush sapheno-popliteal ligation and strip of the short saphenous. The technique of these operations has been described elsewhere (Dodd and Cockett, 1956) and need not be elaborated further.

All these operations should be done with the legs raised slightly above the heart level

The internal ankle perforating veins are approached by an incision which starts half-way up the leg and one finger's breadth behind the posterior border of the tibia The incision is dropped straight down to a point half-way between the internal malleolus and tendo Achillis. The direct ankle perforating veins emerge in the line of this incision and they can be sought and divided as they emerge from their foramina in the deep fascia (the extrafascial operation) or the incision may be carried straight down through the deep fascia and the veins sought as they come between the muscles, under the flap of deep fascia (the subfascial operation) (Linton, 1953).

Choice of operation

Ulcerated legs due to venous disease fall, broadly speaking, into two types.

Localized ulcer near the malleolus

There are legs with a rather localized ulcer near the malleolus When the ulcer is palpated with the patient standing up it can be felt to be—as it were—floating on a bog of veins in the subcutaneous tissues. In the tissues immediately above the ulcer enlarged veins can be felt This type of ulcer (often associated with grossly incompetent veins of the great saphenous system) is best handled by the extrafascial operation The subcutaneous tissues above the ulcer are relatively normal and by dissecting in these, all the dilated veins in the immediate vicinity of, and underneath, the ulcer can be dissected out and removed—a factor which is important for the long-term success and sound healing in this area.

If the ulcer is small, not very indurated and has healed rapidly on pressure bandaging, then it need not be excised. If, however, the ulcer is very chronic (5–10 years or more—now the haemangioma-like lesion) and is locally indurated and will not be quickly and readily healed by pressure bandaging, then it is best excised with full thickness of skin down to the deep fascia

There are three technical points of note in the extrafascial operation.

(1) The lateral dissection in the subcutaneous tissues should be fairly limited—say to about half an inch, not more—on either side of the wound, otherwise a certain amount of skin necrosis may ensue in the post-operative period. This skin necrosis will not mar the final result, but lengthens the convalescence. Perforating arteries should be divided with the veins, as the aim of the operation is devascularization of the area It is not the division of the perforating arteries which causes skin necrosis, it is too much lateral dissection close underneath the skin.

(2) All ligations must be with fine, plain catgut Unabsorbable material like silk or thread must never be buried, otherwise sinuses will result

(3) After excising an ulcer a split skin graft should be sewn in place 3 or 4 days later The reason for this is that if the graft is sewn in place at the original operation it is floated off by haemorrhage in this exceedingly vascular area, in about one-third of the cases If the grafting is delayed 3 or 4 days a good 100 per cent take of graft can be assured.

Indurated ulcerated legs

At the other end of the scale there are the grossly indurated legs, the whole of the subcutaneous tissues from about half-way up the leg on the inner side (the level of the upper ankle perforating vein) down to the malleoli being indurated

and welded into a dense fibrotic mass. There may be diffuse ulceration over this area, or there may be a particularly indurated area with an ulcer just above the internal malleolus. These indurated ulcerated legs are usually the result of post-phlebitic perforating vein incompetence and always the upper internal ankle perforating vein is involved. In these cases there is, for practical purposes, no nice subcutaneous plane in which to dissect, and for these more advanced cases the subfascial operation is undoubtedly the one of choice. The incision, which must start high up over half-way up the leg, in order to be sure of getting the upper

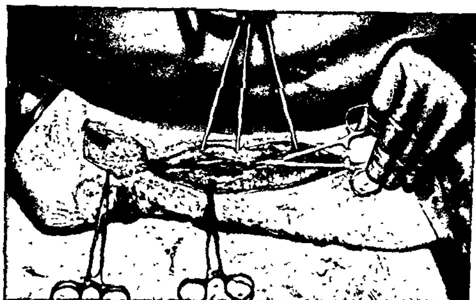


Fig 8.—The subfascial operation. The incision is carried straight down to muscle. The three artery forceps at the top of the photograph are on the flap of deep fascia which is raised anteriorly and underneath which the perforating veins are sought. The artery forceps is under the upper internal direct ankle perforating vein. The two other artery forceps are on the middle and lower internal ankle perforating veins respectively.

ankle perforating vein, is carried straight down through the deep fascia until the muscles bulge out of the incision. The perforating veins are then sought under the fascial flap on each side, as shown in Fig. 8.

A radical division of all perforating veins and perforating arteries must be done throughout the length of the incision as, again, success depends to a large extent on the amount of devascularization of the area which can be carried out. The dissection should be carried anteriorly to the medial border of the tibia and laterally one can burrow round behind the calf if necessary and even tie the lateral perforating vein through this incision.

The indications for excising an ulcer and grafting are as previously stated in considering the extrafascial operation. Occasionally when very large, and circumferential ulcers have been present for a long time, an extensive area of excision of tissue down to the deep fascia may be advisable with extensive grafting.

The operation must be carried out with meticulous aseptic care and again no unabsorbable sutures must be used. The deep fascia need not be sewn up as it always reforms The skin should be drawn together with large, widely spaced sutures which must be left in for at least 10 days Occasionally after making the incision in a very tight, indurated leg the skin gapes and cannot be sewn together again except under extreme tension. In such cases it is better not to sew it up but to leave a long oval defect into which a "gusset" skin graft can be sutured after a few days. This relief of the "tourniquet effect" is often very beneficial and ankle function improves and ankle swelling disappears.

Essential post-operative care for both operations

(1) A dry dressing is put over the wound and then the whole leg from toes to knee is pressure bandaged with a 6-inch crêpe bandage.

(2) The patient must be nursed with the foot of the bed on 10-inch blocks all the time he is in hospital. He must be told not to counteract this antigravitational effect by sitting bolt upright in bed, but must recline on two or three pillows only.

(3) Active knee, ankle and toe movement is instituted from the start.

(4) From the second day onward the patient gets out of bed and walks actively for increasing periods, with leg and foot well supported with a strong webbing elastic bandage, and later an elastic stocking

(5) On discharge from hospital he must continue this régime of graduated activity and webbing bandage support, until he is seen in the follow-up clinic and the wound is judged soundly healed.

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BLOOD TRANSFUSION

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PLASTIC EQUIPMENT

In Britain, transfusion sets made of glass and rubber have so far been used almost exclusively. These sets are robust and since they can be used many times they are economical. One may, however, look at this last feature in a different way and say that glass and rubber sets are too expensive to be thrown away after being used only once. Since it is difficult to clean rubber tubing really thoroughly, particularly when blood has been allowed to dry inside it, it may be seen that the re-usability of rubber tubing is simply a harsh necessity.

Plastic tubing has been available for many years and since it is so cheap that it can be thrown away after being used only once it may be wondered why it has not already replaced rubber. The answer is that plastic is less elastic than rubber and does not fit satisfactorily on to drip chambers and needle hubs. Thus it is necessary to develop a completely new set, made entirely of plastic, so that, for example, the drip chamber is moulded directly on to the tubing of the transfusion set. Since such a set is designed to be used once only, it must, if possible, be cheaper than the present rubber and glass sets.

Sets made entirely of plastic have certain substantial advantages. Since they are used only once they are free from contamination by traces of blood from previous usage This means that not only are they less likely to be contaminated with pyrogens, but that they are also free from the risk of transmitting the virus of hepatitis—a risk which, though remote, is inherent in the re-use of transfusion sets.

Plastic sets are light in weight and transparent. Both these features are advantageous in giving transfusions Being light, the tubing has less tendency to drag on the needle and there is thus less risk that the needle will be displaced; transparency lessens the risk of introducing air into the veins Lightness is also an advantage in handling and transporting large numbers of sets

A further virtue of plastic is that its surface is "non-wettable" and thus, unlike glass, does not promote blood clotting. This advantage will be discussed again below. One further advantage of plastic sets is that all the joints in them are moulded together so that there is very little risk that the set will leak when blood is forced through it under pressure

Types of plastic used

There are 3 types of plastic to consider:

Polythene

Polythene has a melting point of about 110°C. and therefore cannot be autoclaved (the usual temperature of autoclaving being 121°C.). Polythene can be sterilized by boiling, but care must be taken to see that it does not become distorted while hot. Polythene tubing has been used extensively for catheterizing blood vessels and it is known to be non-irritant to tissues (Ingraham, Alexander and Matson, 1947).

New types of polythene (for example, "high density" polythene) with a higher melting point (approximately 125°C.) have now been developed, but these are too hard to be suitable for transfusion work.

Nylon

Nylon is relatively hard, but lends itself well to the construction of, for example, piercing needles. Nylon can be made into a fine thread, and is used in the construction of fine mesh filters It is rather too stiff for the construction of other parts of plastic sets, though sets made entirely of nylon are marketed.

Polyvinyl chloride

Polyvinyl chloride is at present the main constituent of most plastic sets. It is mixed with various plasticizers, for example a small percentage of dioctyl phthalate, and stabilizers, for example organic tin compounds. Plastic of this type is very suitable for transfusion tubing It can be made stiff enough to form drip chambers which are compressible but do not collapse, and flexible enough to make tubing which lies easily in coils, without tending to unwind. The exact composition of the plastic is not usually stated, but it is known that sometimes it contains undesirable substances; for example, it may contain dibutyl tin, which is known to be toxic, instead of the less toxic dioctyl tin (Barnes and Stoner, 1958; Barnes, 1958).

Silicone rubber

Despite the name of this material, it contains no natural rubber, but is made entirely from silicones. This kind of tubing has certain advantages for transfusion equipment (Wilkinson, Freeman, New and Noad, 1956) Like plastics, it has a non-wettable surface, and it is lighter in weight than normal rubber tubing. It also has disadvantages: it is much too expensive to be thrown away after a single use, and when it is autoclaved repeatedly it stretches and may then fail to fit needle hubs satisfactorily (Tovey and Tovey, 1958)

Design of plastic transfusion sets

A set which has already come into limited use in the United Kingdom is illustrated in Fig 9 The design of this set was influenced by trials carried out by a sub-committee of the Medical Research Council (Report to the M.R.C., 1957). The set is clearly a descendant of sets which have been used for many years in the United States of America. However, it has some novel features: the air inlet needle, which is made of metal, is incorporated in the wall of the plastic outflow tube;

the air inlet needle projects half an inch beyond the tip of the outflow tube, so that when it is in the bottle air enters well above the point of outlet of the blood; this is important because it makes it impossible for air to be sucked down the outflow. Moreover, the projecting air inlet needle makes a very good piercer, preceding the plastic outflow needle when both are pushed through the rubber stopper of a bottle.

The air inlet needle is connected to a length of plastic tubing which ends in a female Luer adapter; this adapter has a small hook attached to it which can be

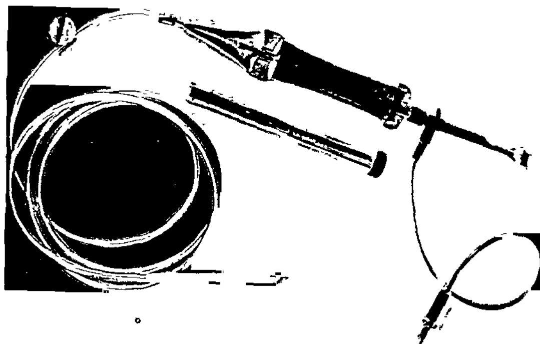


FIG 9—Ph [illegible] in the
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used to fasten the end of the tube on to the band round the bottom of the bottle when the bottle is hung up A small wad of cotton wool is inserted in the distal end of the air inlet tube to serve as a bacterial filter.

The filter chamber and drip chamber of the set are compressible. This makes it easy to expel air from them in order to fill them with blood or, alternatively, to expel blood and then, with the bottle on its base, suck in some air if the drip chamber gets too full of blood

The diameter of the plastic tubing is 4 millimetres, that is to say, about the same as that of the rubber tubing which is in use at present, but wider than that of most other plastic transfusion sets (3 millimetres). The advantage of the greater diameter is that the rate of flow through the set is slightly increased.

The tubing is coupled at its distal end to a short length of rubber tubing into which injections can be given; the rubber tubing is in turn connected to a male Luer adapter which can be joined directly to a needle or cannula, or can be used with the needle assembly supplied; this consists of a female Luer adapter joined by a short length of plastic tubing to a 17-gauge needle. Many people find that it is easier to handle a needle when it is connected to a short length of tubing. The external surface of the needle assembly is sterile since it is protected by a glass test-tube from which it can be dropped on to the gloved hand of the operator. Thus, only the needle assembly need be handled by somebody who is trying to remain "sterile". The rest of the set is sterile only on the inside and at its ends, which are protected by plastic sheaths.

Plastic sets and thrombophlebitis

In long-continued blood transfusions there is a clear advantage in using plastic transfusion sets rather than sets made of rubber. This was shown by the Report of the Medical Research Council's Committee (1957) and is illustrated in the following Table, taken from their report.

TABLE

INCIDENCE OF THROMBOPHLEBITIS AFTER INFUSIONS THROUGH PLASTIC AND RUBBER TUBING (FROM REPORT TO MEDICAL RESEARCH COUNCIL, 1957)

	Percentage of cases after infusions lasting			
	0–12 *hours*	13–23 *hours*	24–47 *hours*	48 *or more hours*
Plastic	nil	13	37	48
Rubber	nil	26	55	82

(*By courtesy of the Editor of The Lancet*)

Like previous observers, the Committee noted that there were no cases of thrombophlebitis associated with infusions lasting for 12 hours or less. In infusions lasting for more than 12 hours the incidence of thrombophlebitis was closely related to the duration of the infusion. The incidence of thrombophlebitis was almost twice as high when rubber sets were used as it was when plastic sets were used

It has been claimed that the use of silicone rubber tubing is also associated with a low incidence of thrombophlebitis; however, the only trials published so far have related to infusions lasting for less than 12 hours. As already mentioned, such infusions are associated with a negligible incidence of thrombophlebitis, even when rubber tubing is used. Tovey and Tovey (1958) have found that when infusions lasting more than 12 hours are given through silicone tubing thrombophlebitis is not uncommon

Plastic containers for blood

In the United States of America plastic containers for blood (plastic bags) have been under trial for almost 10 years. The fact that they are still not standard equipment suggests that their advantages for routine use are not great enough to offset their increased cost.

Two of the most important claims made for the bags are: first, that compared

with glass containers they cause less damage to platelets; and second, that they permit better preservation of red cells. Of these two claims the first seems soundly established. For example, in a recent paper Adelson, Rheingold and Crosby (1957) compared the survival of platelets from blood drawn into all-plastic equipment with the survival of platelets drawn through rubber tubing into ordinary glass bottles. When plastic equipment was used, 50 per cent of the platelets were still present in the recipient's circulation 2 or even 3 days after transfusion By contrast, when blood drawn into glass bottles was transfused; the number of surviving platelets 12 hours after transfusion was negligible.

On the other hand there is no good evidence that when blood is stored in plastic bottles the viability of the red cells is better maintained than when blood is stored in glass. It may be worth pointing out that the rate of deterioration of red cells during storage varies considerably from one donor to another. Thus, if red cells from "good" donors are stored in plastic, and by chance their survival is compared with that of red cells from "bad" donors stored in glass, false conclusions may be (and have been) drawn When small numbers of cases are being compared, the only safe course is to use each donor as his own control by storing his cells first in glass, then in plastic, or *vice versa*. In a trial of this kind Dudley, Richmond, McNair, Paton and Cumming (1958) showed that results in plastic and glass were the same.

One batch of plastic bags tested by Strumia, Colwell and Ellenberger (1955) had an adverse effect on red cell preservation Now, before plastic bags can be sold in the United States of America, the manufacturer is required to submit evidence, derived from experiments with bags made from 3 different compoundings of the plastics, and when blood is stored in the bags for 21 days at +5°C., red cell survival 24 hours after transfusion is 70 per cent or better.

In some plastic equipment the donor tube is an integral part of the bag and remains attached to it after the blood has been drawn off. This arrangement minimizes the risk of contaminating the blood, but is potentially wasteful since, if venepuncture of the donor is unsuccessful, the whole bag must be discarded.

[illegible] there is less clot formation when blood is collected [illegible] single giving set (recipient [illegible] that when a second lot of blood was given through the same set the rate of flow was much reduced.

One considerable attraction of plastic bags is that they contain no air, so that when they are compressed, to speed the rate of transfusion, there is no risk of air embolism. Dudley and his colleagues found that with "two-handed pressure" they could give blood at the rate of 155 millilitres a minute. This was faster than the rate achieved using air pressure with a standard glass bottle and a plastic transfusion set (116 millilitres a minute) but considerably less rapid than the rate achieved by using air pressure in combination with a standard glass bottle and standard glass-rubber giving sets (394 millilitres a minute)

For giving blood at very rapid rates it seems that the rotary pump remains the safest and most satisfactory method. Most pumps will require modification before they can be used with plastic tubing; one simple method is to split a length of rubber tubing and use it to encase the plastic tubing where it passes through the rotary pump.

CITRATE TOXICITY

When citrate was first used in blood transfusion it was treated with respect, and the dosage was kept to a minimum For example, Lewisohn (1915) used to add 1 gramme of citrate to 500 millilitres of blood. Later on it became common to use 2 or 3 times as much citrate as this: it was found that even when 1 litre of blood, containing 5 or 6 grammes of citrate, was transfused rapidly (30 minutes) no toxic signs attributable to citrate were observed. The opinion grew up that citrate was extremely safe and that the likelihood of citrate intoxication during transfusion was virtually non-existent.

In the last 10 years several procedures have been introduced which involve giving blood at rates not previously envisaged The first of these is exchange transfusion carried out in a newborn infant. In this procedure it is common to inject a volume of blood equal to twice the infant's own blood volume. If 500 millilitres of whole citrated blood (containing 2 grammes disodium citrate or 8 millimols citrate) are transfused in 90 minutes to an infant weighing 3 kilograms the dose may be expressed as follows:

$$\frac{8}{90\times 3} \text{ per kilogram per minute, that is, 0 03 mM per kilogram per minute.}$$

This rate of administration has been shown to cause changes in the conductivity of the heart muscle shown by a prolongation of the S-T segment in the electrocardiogram (Gustafson, 1951).

It is not uncommon for citrated blood to be given to infants far more rapidly than this, and it seems likely that citrate intoxication is responsible for the sudden deaths which occur occasionally during exchange transfusion. The danger of citrate toxicity can be significantly diminished by removing much of the supernatant citrated plasma, and giving packed cells If signs of citrate toxicity do develop, they can be reversed by the administration of calcium (Furman, Hellerstein and Startzman, 1951; Gustafson, 1951); most operators prefer to give calcium prophylactically (approximately 2 millilitres of 10 per cent calcium gluconate for every 100 millilitres of citrated blood)

To achieve a rate of citrate administration of 0 03 mM per kilogram per minute in an adult weighing 60 kilograms one would have to give 1,000 millilitres of blood in 5 minutes In a subject with unimpaired liver function and with no mechanical obstruction to the hepatic circulation such a rate of administration is reasonably safe. In dogs, when citrate is administered at twice this rate (0 06 mM per kilogram per minute), the administration must be continued for about 20 minutes to kill the animal (Adams, Thornton, Allen and Gonzalez, 1944)

Nevertheless, lesser rates of administration may be very dangerous under some circumstances. Thus, in subjects with severe liver disease or with mechanical obstruction to the hepatic circulation, Bunker and his colleagues (1955) found that the plasma citrate level rose to higher levels than in normal subjects. They calculated that in 5 such patients transfused with relatively small amounts of citrated blood, the concentration of ionized calcium fell to 0·6 mM per litre (normal 1 0 mM per litre). A level of 0 6 mM per litre must be regarded as very dangerous in view of the fact that at a level of 0·5 mM per litre the isolated frog's heart stops beating (McLean and Hastings, 1934) and clotting time is prolonged (Stefanini, 1950).

Hubbard, Neis and Barmore (1956) have recorded a dramatic case of severe citrate intoxication developing during cardiovascular surgery. The signs were the usual electrocardiographic ones, indicating interference with conductivity, and a progressive fall in blood pressure (Nakasone, Watkins, Janeway and Gross, 1954). Within 3 minutes of injecting 4 millilitres of 10 per cent calcium chloride into the right ventricle, the electrocardiographic changes were partly reversed, and the blood pressure had risen A further 5 millilitres of calcium chloride intravenously restored the blood pressure to normal. When large amounts of citrated blood have to be given rapidly, as during cardiovascular surgery, there is obviously an advantage in having a continuous recording of the electrocardiograph.

Another circumstance in which citrate may be very dangerous is when blood is being introduced directly into the aorta. This is also one of the few circumstances in which the raised potassium content of the plasma of stored blood may be dangerous. Both these risks can be overcome by using fresh heparinized blood, but evidently the amount of heparin that can be administered during major surgery is limited.

In a recent paper Firt and Hejhal (1957) have suggested that when it is anticipated that blood will have to be given very rapidly (at rates like 500 millilitres per minute) 10 millilitres of 10 per cent calcium gluconate should be given before transfusion, with a further 15 millilitres intravenously given after the transfusion has begun, and a further 10 millilitres after every 500 millilitres of blood.

Incidentally, when calcium is administered it should normally be given into a separate vein. When this is inconvenient, as in exchange transfusion in infants, the calcium can be injected through the transfusion needle (or cannula) provided that it is preceded and followed by a little heparinized saline.

PRESERVATION OF RED CELLS

Optimal temperatures for normal storage

Blood is commonly stored at a temperature of about +4°C. This temperature is presumably chosen on the assumption that blood should be kept as cold as possible without running the risk of its freezing, although some investigators have come [illegible] temperature several degrees above zero (+7°C.) is actually [illegible] z, Parpart, Gregg and Chase, 1947). [illegible] of temperature in the range +10°C. to —10°C. on red cell preservation has recently been published (Hughes Jones, 1958b) It was possible to study the effects of temperatures below the usual freezing point by including glycerol in the solution added to the blood. It was found that preservation improved steadily as the storage temperature was lowered. Thus, after 34 days' storage, the average percentage survival of the red cells, 24 hours after transfusion, was as follows +10°C., 52 per cent, +4°C., 63 per cent; —2°C., 78 per cent; and —10°C., 80 per cent.

Blood mixed with the usual anti-coagulant solution (acid-citrate dextrose) freezes at about —0·5°C., and can be super-cooled to —3°C. and maintained at that temperature indefinitely without freezing (Strumia, 1954).

In practice, the risk of freezing must be avoided, and hospital blood banks would be wise to continue to use a temperature a few degrees above 0°C. Nevertheless, it

does seem that in large blood banks in which the storage temperature can be rigidly controlled it would be more logical to use a temperature of approximately 0°C

Storage in the frozen state

If sufficient glycerol is added to red cells they can be frozen and thawed without haemolysis (Smith, 1950). When stored at a temperature of —45°C. or lower, red cells mixed with glycerol maintain their viability almost unimpaired for periods of at least 1 or 2 years (Jones, Mollison and Robinson, 1957; Chaplin, Schmidt and Steinfeld, 1957; Mollison and Robinson, 1958).

The usefulness of this method of storage is at present severely restricted by the absence of any convenient means of removing the glycerol from the cells, which must be done before the cells can be transfused. However, the prototype of a centrifuge which will wash red cells continuously in their original containers has recently been described (Mollison and his colleagues, 1958). With this machine red cells can be prepared for transfusion at 3 hours' notice, so that further developments may make sub-zero storage a useful procedure in special circumstances

Addition of purine nucleosides

Although most blood is used for transfusion after it has been stored for less than 2 weeks it is sometimes necessary to use blood a little older than this. When mixed with the standard preservative solution (ACD) and stored at +4°C. red cells start to deteriorate rather rapidly during about the fourth week of storage Thus, the discovery that the addition of purine nucleosides (adenosine, inosine) considerably retards the rate of deterioration is of great interest (Gabrio, Hennessey, Thomasson and Finch, 1955). The most striking difference is seen after about 7 weeks' storage In blood stored for this period in ACD alone only about 10 per cent of the red cells are still viable; however, in blood stored with ACD and adenosine, about 70 per cent of the red cells are still viable (Donohue and Finch, 1957).

Adenosine itself is too toxic for routine addition to stored blood; inosine is likely to prove safe, but so far it has proved difficult to obtain reproducible results with it (Finch, 1958) Guanosine also has a low toxicity, and is also capable of rejuvenating stored red cells, but it has so far proved impossible to obtain consistently successful results (Prankerd, 1956a and b).

VALUE OF RADIOACTIVE CHROMIUM AS A RED CELL LABEL

Radioactive chromium has proved to be of great value as a red cell label in the solution of clinical problems. Red cells, either the patient's own or red cells from a donor, can be labelled *in vitro* and be ready for re-injection within 1 hour. The label leaks out of the red cell relatively slowly, so that reliable estimates of red cell survival can be made Very small volumes of red cells can be labelled, and thus is a great advantage in testing compatibility in doubtful cases. If red cells are removed from the circulation preferentially in some particular organ, for example the spleen, this can be detected by counting over the surface of the body with a scintillation counter If blood is lost into the gut, the label is excreted in the stools (with virtually no reabsorption) so that the extent of the blood loss can be accurately determined. A few applications of ^{51}Cr labelling are as follows:

Biological test for red cells incompatibility

When the indirect antiglobulin (Coombs') test is included in the direct matching procedure, it is usually possible to be confident whether or not a particular sample of red cells is compatible with the recipient's serum. However, occasionally there is doubt, and in such cases the question can be decided with certainty by performing an actual estimate of red cell survival, using less than 1 millilitre of the donor's red cells labelled with radioactive chromium. A small sample of the patient's own red cells is labelled with ^{32}P and injected simultaneously as a control (Mollison and Cutbush, 1955). Using this method it has been possible to show that specific "cold" agglutinins sometimes bring about the destruction of transfused red cells (Cutbush and Mollison, 1958).

Indications for splenectomy

In patients with chronic leukaemia it may be possible to maintain a satisfactory haemoglobin level in the blood only by giving repeated transfusions. In such cases splenectomy sometimes greatly diminishes transfusion requirements. Selection of cases for operation is made more reliable if the role of the spleen in red cell destruction can be estimated. In some cases reported by Hughes Jones and Szur (1957) in which the spleen was shown, after the injection of ^{51}Cr-labelled cells, to be playing a major role in red cell destruction, transfusion requirements after splenectomy were greatly reduced.

Estimation of blood loss in the stools

In patients who are known to be bleeding into the gut the question may arise whether the blood loss in the stools can account completely for the transfusion requirements. In such cases a sample of red cells may be labelled with ^{51}Cr and injected intravenously; the rate of loss of ^{51}Cr from the blood is determined by collecting venous samples, and the amount of blood lost into the gut is determined by estimating the ^{51}Cr content of the stools. In some cases investigated in this way by Hughes Jones (1958a), when the blood count was corrected for loss in the stools it fell within normal limits, showing that there was no increase in the destruction of red cells.

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ABSTRACTS RELATING TO BLOOD TRANSFUSION

Haemorrhage and shock

Recent advances

CLARKE (1957) described recent advances in haemorrhage and shock. In 1919, Cannon posed the question of the "lost blood in shock", assuming it to be static in the capillaries. By 1946, it was postulated that shock merely represented loss of blood from the circulation, an over-simplification. Emphasizing the extent of haemorrhage and the role of early rapid transfusion in large wounds, Grant and Reeve (1951) concluded that the word "shock" was misleading and existing theories were inadequate. Today, evidence shows

trievably lost from the circulation as a result of injury and is not due to capillary stasis. Any patient who has lost more than 2–4 pints of blood requires its replacement, not only to combat shock but to permit more adequate primary surgery and facilitate the course of the illness. The tradition of "hot sweet tea" is rejected, since the administration of fluids or solids may lead to vomiting and disaster under subsequent anaesthesia. The

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mainder, 193 returned for follow-up examination, among these, there were ... hepatitis and 5 in whom the diagnosis was "possible". In the control group of 603 who were followed-up, no cases of serum hepatitis were recognized, although 2 were considered

"possible". Of 10 patients who developed serum hepatitis after transfusion of "high thymol" blood, 9 were jaundiced The clinical diagnosis of serum hepatitis is often difficult Proof of its existence includes clinical evidence, liver biopsy and transmission to human volunteers The findings described here, based on the clinical and laboratory features and characteristic of the disease, clearly indicate that the hazard of serum hepatitis is greatly increased when blood from "high thymol" donors is used. At the same time, no claim is made that the test will eliminate the possibility of serum hepatitis, or detect all its asymptomatic carriers The authors know of 10 cases which developed after transfusion of blood known to be negative for thymol turbidity. The incidence of serum hepatitis, however, could probably be greatly reduced if the test were used routinely for screening blood donors

Blood donation

Infective hepatitis

MATTHES and RIDERER (1957) discussed blood donation after hepatitis. In Western Germany, the blood transfusion service excludes for 6 months as a donor any person [illegible]

53 donors had given 250 transfusions to 186 patients. After 6 months, a questionnaire revealed that 58 patients had died of their primary disease Of the remaining 128, 13 had contracted jaundice within the incubation period of hepatitis. A control group of 50 [illegible]

resistance of the remainder [illegible]

than 5 years had elapsed, the incidence was no higher than in the controls Donors therefore should be debarred from giving blood for a minimum period of 5 years after an attack of hepatitis, if indeed they should ever be eligible.

Bacterial contamination of blood

Effects of temperature

JAMES and STOKES (1957) carried out experiments to determine the effects of [illegible]

were in use [illegible]
blood [illegible]

for a short time before storage might be a useful precaution but it was necessary to show that blood cells would not be damaged by this and that bacteria which grow best at 37 C. could not multiply in such conditions. Experiments were made in which fresh blood was inoculated with various organisms in such strength as would correspond to about 500,000 viable organisms in a bottle, but there was no evidence that growth occurred during 2 hours' incubation. Although some suggest that contamination from the air is a serious risk when blood is taken by a closed method no proof of this was found. Tests were made to measure the rate of growth of organisms in heavily contaminated blood during slow cooling at room temperature. Early refrigeration did not seem to hinder growth. The most dangerous contaminants were, as already stated, those which grow in the cold and though the addition of tetracycline to the blood has been suggested the writers are not in favour, pointing out that antibiotics are unstable and that fatalities in sensitive persons might occur. A short period of storage is ideal but it was observed that in 16-day samples sterility could be guaranteed thereafter if no growth had already developed. Bottles returned to the laboratory after transfusion were also tested and a special technique was evolved which is described in detail. No great benefit could be shown to occur if refrigerator vehicles were used for transporting samples collected and, provided that refrigeration is done within 8 hours of collection, satisfactory results are obtained in temperate climates. In the tropics a limit of 2 hours is preferable.

Blood banks

Safety device for refrigerators

PENISTAN (1957) described a safety device for refrigerators in blood banks. As an alarm system is rarely fitted blood may be wasted if a thermostat fails. His device makes use of the recording thermometer which is itself made into a thermostat and works a light or sound signal when voltage is low. Most recording thermometers have a moving arm to which a nib is fixed to make the temperature record. It is a simple matter to attach to this arm a device whereby, at certain points, it makes an electrical contact which sets off the alarm. It is necessary to cut the glass of the recording thermometer so that a slit is made at right angles to the recording arm and the contact pins are fixed in this slit in such a way that a current passes when the upper or lower safety temperatures are reached. The electrical circuit to the alarm or light is easily made on conventional lines and power is given by a small battery or by using a transformer on the main. It is convenient to have both a sound alarm and a warning light operated simultaneously. Installation costs are small.

Standard blood transfusion giving set

Simple metal retaining cap

BISHOP (1957) described a simple metal retaining cap for the standard blood transfusion giving set. The standard mantle is normally held in position by a rubber stopper in the neck of the glass bottle, adhesive strapping prevents the stopper from slipping. In the device described, a small metal cap fits over the stopper and screws on to the neck of the bottle. It has a small round hole in its top, through which pass the outlet and inlet tubes. This hole is slightly smaller than the diameter of the stopper, which is thus supported round its perimeter. Once the mantle of the set is firmly inserted into the bottle, the cap is readily screwed into position and the rubber stopper secured.

Haemolytic transfusion reactions

Nature of haemorrhagic disorder

The nature of the haemorrhagic disorder accompanying haemolytic transfusion reactions in man was discussed by KREVANS and his colleagues (1957). A study has been made of 2 patients who developed abnormal bleeding after the inadvertent administration of 500 millilitres of incompatible whole blood. The methods used included: determinations of haematocrit on venous blood; platelet counts, determinations of bleeding times, whole blood clotting times and prothrombin times, tests for capillary resistance and whole

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observations, the entrance of thromboplastic substances into the circulation may result

have shown that platelets do not seem to be necessary for intravascular coagulation following an incompatible transfusion reaction.

Febrile transfusion reactions

Association with leuco-agglutinins

results showed the presence of LA in 32 instances, in contrast, red cell antibodies were demonstrable in only 7 patients, in 5 of whom both red cell and white cell antibodies occurred simultaneously; red cell antibodies in the absence of LA were found in only 2 instances. An analysis of the data demonstrated the close relationship between the occurrence of LA and the number of transfusions. There was no correlation between diagnosis and such findings. as in earlier work, all the diseases were those in which transfusions were given therapeutically, the diseases were not confined to blood dyscrasias. An additional group of 8 patients with allergic (urticarial) manifestations after transfusions were studied; no evidence of LA or red cell antibodies was found In cases receiving multiple transfusions during several months, LA were often observed at about the same time as the first febrile transfusion reaction. they usually developed after 8 or more transfusions Administration of "leucocyte-free" blood failed to provoke febrile transfusion reactions in patients with a history of reaction.

Post-transfusion thrombocytopenic purpura

Case report

MICHEL (1957) presented a case of post-transfusion thrombocytopenic purpura This is

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calculus Blood pressure was 180/100 millimetres of mercury. Because of anaemia and anticipated surgical blood loss, she received 1 unit of blood without reaction. During

operation she again received 1 unit, shortly followed by another. Hypotension developed, the wound bled, substernal pain and pain in the neck occurred. Another unit of blood maintained the systolic blood pressure between 110 and 120 millimetres of mercury. Purpura developed round the incision and there was marked haematuria. Blood platelets were seen to be greatly decreased and 2 more units of blood were given. Petechiae were now observed. The platelet count was 40,000 per cubic millimetre; bleeding time, 11½ minutes; clotting time, 8 minutes The Rumpel-Leeds test was positive. Two more units of blood were given and a course of hydrocortisone hemisuccinate begun. The platelet count began to rise and on discharge was 220,000 per cubic millimetre. Donor blood was investigated for platelet antibodies. Of the 2 donors giving blood immediately prior to the thrombocytopenic reaction, the former had given it 6 times. The latter, who had never given blood, was found to be suffering from Boeck's sarcoid Platelet suspensions and serum tests revealed that his serum would cause agglutination of the patient's platelets, and it did so in 5 volunteers Since the immunological reactivity of patients with sarcoidosis shows an increased ability to manufacture circulatory antibodies, these patients should be debarred from blood donation.

Citrate intoxication

Cardiovascular surgery

HUBBARD, NEIS and BARMORE (1956) reported a case of severe citrate intoxication during cardiovascular surgery. Citrate intoxication has become a common problem during large transfusions, haemorrhage and vascular surgery. A progressive fall of the ionized calcium level in the blood may cause tetany, hypotension and cardiac arrest. The characteristic warning signs of muscle tremor and tetany are, however, usually absent in deep shock or surgical anaesthesia. Since there is no readily available laboratory procedure for determining the ionized calcium blood level, the electrocardiogram provides the best indication In the case described, a woman of 24 years with the tetralogy of Fallot was undergoing an infundibular resection. At the beginning of operation the systemic blood pressure was 98/65 millimetres of mercury; the right ventricular pressure, 110/5 millimetres. Blood was infused under pressure according to the estimated amount lost at cardiotomy. During the first 15 minutes of resection the blood loss was about 500 millilitres; an additional 250 millilitres produced definite prolongation of the corrected Q-T interval, which was disregarded. With continued transfusion citrate intoxication became apparent, with falls in the right ventricular and systemic arterial pressures and further prolongation of the corrected Q-T interval Further electrocardiographic changes were observed during a technical delay in administering calcium. Despite an increased rate of infusion, the systemic blood pressure became unobtainable. A period of cardiac arrest was corrected by massage and 4 millilitres of calcium chloride were injected directly into the right ventricle. Within 3 minutes blood pressure rose to 80/60 millimetres. A further intravenous calcium chloride injection of 5 millilitres raised it to 110/85 millimetres, while the electrocardiogram returned to the original configuration. The post-operative course was uncomplicated.

Dextran infusions

Blood volume changes

Blood volume changes after infusion of dextran solutions were described by KOSTER and his colleagues (1957). Restoration of blood volume to a normal level is a prime aim in treating shock, and the writers made experiments to determine a reliable method for estimating blood and plasma volume after dextran infusions and for estimating serum albumin levels immediately after the preparation was used. Allergic reactions to dextran are rare in persons whose blood volume is much reduced but fairly common when it is about normal. Such reactions are followed by a marked drop in plasma volume and some writers suggest that this is due to the proteins being "squeezed" out of the capillaries. Should this phenomenon occur it would be a handicap, particularly in treating burns. As serum albumin labelled with radio-iodine behaves just as the normal substance it was used to facilitate estimations after dextran had been given. With various strengths of

dextran varying immediate changes in blood volume occurred, but in general the writers found that 1 gramme of dextran retains about 18 millilitres of fluid. The immediate

Acute fibrinogen deficiencies

Mechanisms of production

The mechanisms of production of acute fibrinogen deficiencies were discussed by

too rapidly to be explained otherwise than by active depletion of the circulating fibrinogen; definite evidence of "fibrination" as a cause of defibrination was first obtained when intravascular fibrin occlusions were demonstrated in a woman who died soon after

hydatidiform mole during uterine contractions, pressure changes may break down the barrier between degenerating and viable portions of the mole, allowing exit of a crude tissue autolysate through the intervillous lake into the maternal circulation; somewhat similar circumstances are present in "the dead foetus syndrome"; a haemorrhagic tendency is sometimes observed also in association with amniotic fluid embolism; as amniotic fluid contains thromboplastin, defibrination may occur in these cases through fibrination initiated by thromboplastin, in a manner analogous to that applying in *abruptio placentae*. There are conditions in which fibrination occurs but in which no fibrin deposits are

from these cases to coagulate in the cold is sometimes observed as it is in drawn blood and its plasma from cases of severe toxaemia of pregnancy or *abruptio placentae*, and in blood drawn from dogs following injection of tissue thromboplastin extracts; whether this tendency indicates an increased level of coagulation in the circulating blood is uncertain; in cases of haemolytic reaction following water infusions, investigation might be made of whether, in addition to simple haemolysis, the irrigating fluid may act as an auto-extracting medium, carrying into the circulation significant quantities of tissue materials including thromboplastin or of fibrinokinase.

Haemophilia

Animal antihaemophilic globulin

human A.H.G. to all haemophiliacs to maintain their plasma level at a safe concentration, the number of donors needed would be impossibly large. Experiments were therefore *made in Oxford to see if animal blood could be used instead*, and in the best samples a potency 8,000 times as great as that of the human product was found. But some unavoidable contamination with fibrinogen and other proteins was noted and the antigenic properties thus present limit the use of the animal product to 10–14 days. Three volunteer *haemophilic patients were given it when they needed dental extractions and in 2 of these* very good results were noted The third patient, an epileptic, had a low platelet count,

of preparation are given by the writers who also describe precautions used to prevent allergic reactions In their next 4 cases dental extractions were made under cover of animal ... had a powerful

interventions and 2 out of 5 died, 1 having marked coronary atheroma. In their second group minor surgery was needed for 4 patients, 3 of whom were severely affected. How- ... was available, it was felt reasonable to use plasma and ... proved

kept in mind.

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FLUID AND ELECTROLYTE DISTURBANCES

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During the last 5 years there has been a notable and subtle change in the general attitude towards disturbances in the water and mineral content of the body of the surgical patient after operation and during the course of various complications of disease and operative treatment This change in surgical outlook results from the additions to our knowledge of the mechanisms of various body fluid disturbances which have been made possible as much by the flame photometer as by the deepening and more widespread interest in the physiology of the surgical patient. The recent tendency to reduce the frequency of post-operative intravenous infusion as well as the volume of fluid administered may be due partly to a better understanding of the normal metabolic response to injury and the ability of the body to recover without much external assistance, but is also in part no doubt related to the desire to avoid the chemical thrombophlebitis which is so often a troublesome and painful complication of the prolonged intravenous infusion of glucose solution. The most important recent advances in knowledge of the control of distribution and content of minerals and water in the body concern the part played by the hormones of the adrenal cortex; the measurement of the quantities of certain of these hormones in the blood and urine of patients and experimental animals by biological assay and by partition chromatography has provided information which, although often imperfect, has increased our understanding of some aspects of the response to injury and inflammation.

BLOOD VOLUME

Some method of estimating accurately the blood volume of a patient has many obvious advantages in the management of surgical patients, but few surgical units are equipped to make direct measurements of blood volume as a matter of routine. Although Gibson and Evans (1937) showed that in subjects of average nutrition the blood volume was closely related to height, Hardy and Drabkin (1950) found that, depending on the fatness of the individual, blood volume might vary from 70–105 millilitres per kilogram of body weight and even larger variations have been reported by Allen and his colleagues (1956). After examining the data

from a large number of their own and other published determinations of blood volume, Allen and his colleagues concluded that the fat content of the body was the most important variable factor, and that blood volume was more closely related to a combination of body weight and the cube of the height than to surface area; in other words, to a cubic rather than a square function. From their collected data they were able to derive formulas from which can be calculated not only the blood volume but also the fat content of any individual body. They have found that their method of calculation is applicable and accurate in spite of variations in race, age, sex, wasting, obesity, and the effects of endogenous sex hormones. *In infancy and young children before puberty there is no variation between sexes.* In non-pregnant women the blood volume is about 600 millilitres less than in males of similar height and weight, but in pregnancy it is a litre more. There are also variations according to the phase of the menstrual cycle. In both sexes blood volume declines with age. The formulas for blood volume are as follows:

Men and boys B.V. $= 0.417\ H^3 + 0.0450$ T.B.M $- 0.030L$

Adult women B.V. $= 0.414\ H^3 + 0.0328$ T.B.M $- 0.030L$

The formulas for fat content are:

Males A $= 0.685$ T.B.M. $- 5.86\ H^3 + 0.42$ Kg

Females A $= 0.737$ B.T M. $- 5.15\ H^3 + 0.37$ Kg

Where B.V = blood volume in litres; H = height in metres; T.B.M. = body weight in kilograms, and A = fat content in kilograms.

With the help of these calculations the general bodily state of an individual patient can be compared with his previous state in health By measuring the actual haematocrit or packed cell volume, changes in total red cell volume and plasma volume consequent on disease can be estimated with an accuracy which closely approaches that obtained by direct measurements of plasma or red cell volume with tracer substances. The remarkable tendency of the blood volume of mammals to remain more or less steady within rather narrow limits is well known, and the speed with which some species can restore a depleted blood volume to within normal limits is sometimes a source of difficulty and confusion in experimental work. Even when a litre or more of whole blood is withdrawn from the human subject, the total blood volume may be restored to normal within 72 hours. Conversely, over-transfusion fails to produce a lasting increase in the blood volume of normal subjects (Seavers and Price, 1949), the increment after 24 hours amounting to not more than the volume of cells which have been transfused. The transfusion of excessive volumes of whole blood is followed by the loss of the equivalent of much of the administered plasma and some of that already in circulation, but there is usually a large increase in red cell volume. When excessive volumes of dextran are administered, blood volume is maintained near the normal by th [illegible] the d [illegible] tion, [illegible] compensatory mechanism to maintain total blood volume near the [illegible] (Wilkinson and Storey, 1953) *rather than of an* inhibition of albumin formation.

The effects of severe chronic wasting disease on the volume and composition of the blood and on whole body composition have been described by McMurrey and his colleagues (1955) The weight losses of their patients averaged *over 20 per cent*

of normal healthy weight for their age group. Plasma volume was 120 per cent of normal for the observed weight, but 91 per cent of the normal for healthy weight. Red cell volume was 87 per cent of normal on observed weight, but 67 per cent on healthy weight, with the result that although blood volume was 107 per cent of normal for the observed weight it was 83 per cent by healthy weight There were striking similarities in the changes in plasma volume, extracellular fluid volume and total exchangeable sodium, which were all near normal for the healthy weight and 120 per cent or more of normal for the lower observed weight. Total red cell volume, intracellular water and total exchangeable potassium also were closely associated, being 70–80 per cent of normal on observed weight and 60 per cent on healthy weight. Thus, in chronic wasting disease, extracellular fluid and plasma volumes, and total sodium content hardly diminish, whereas intracellular water, red cell volume and total potassium are much reduced. Similar observations on blood volume have been recorded by Wiklander (1957). All the protein fractions in the body are in equilibrium with one another, and the reduction in the protein of the lean tissue mass is accompanied by reduction in red cell mass and in the total quantity of plasma protein; although plasma volume does not fall in wasting disease, there is a reduction in the concentration of the plasma proteins, especially of albumin Attempts to raise the plasma protein concentration by the infusion of whole plasma or of albumin are unlikely to succeed because protein administered in this way enters into the common metabolic pool of protein. Much of it is rapidly removed from the circulation in a few hours and very large quantities must be given to produce any lasting effects on the concentration of protein in the circulating plasma

SHOCK DUE TO BLOOD LOSS

Loss of blood is the commonest cause of shock after accidental or surgical injury. Estimates of blood loss during operations are nearly always too low unless based on previous experience of direct measurement of blood loss Perhaps the most convenient way of doing this is by washing out all the swabs, towels and gowns in a known volume of water to which is added any blood in the suction bottle; the haemoglobin content of this fluid is measured directly or after conversion to acid haematin. Combined with the average haemoglobin content of the patient's blood before and after operation, the blood loss can be calculated and the volume of blood which should be transfused can be judged. This method does not make any allowance for blood lost into loose areolar tissue in the extraperitoneal or extrapleural tissues, and care must be taken to swab out all blood in the pleural or peritoneal cavities at the end of the operation. After accidental injury direct measurement of blood loss is seldom possible, but it is important for the surgeon to be aware of the probable magnitude of the bleeding. Grant and Reeve (1951) suggested that the size of the wound might be measured by comparison with the hand or fist, and thus a close approximation of the blood loss could be reached. Clarke, Topley and Flear (1955) measured the increase in volume of injured limbs and also total red cell volume before treatment began, and established a close agreement between these two measurements and confirmed the well-known quantitative relationship between muscle injury and blood loss. Towards the end of World War II it became increasingly recognized that even with generous transfusion of blood and adequate surgical treatment of the wounds some injured men

did not respond well, and that a small proportion of them died. Many surgeons have doubted whether more rapid transfusion of still larger volumes of blood would have saved such men, and the cause of this type of disturbance has remained undecided. The experience of Prentice and his colleagues (1954) in Korea during 1952–53 has provided valuable information regarding the effects of transfusing battle casualties with very large volumes of blood; they measured red cell or plasma volume after injury and at various stages during the treatment of 53 patients, and compared these results with the normal volumes calculated from body weight. They found that the post-operative blood volume was nearer normal in patients with abdominal wounds than in those with wounds of the limbs. After injuries of the limbs, as the total quantity of blood transfused rose so did the difference between the patients' red cell and plasma volumes and the volume transfused. In spite of a measured deficiency in blood volume, compared with the calculated normal, of up to 25 per cent even after transfusions of 20 pints, the general condition of the patients was good. Apart from suggesting that much of the apparently lost blood might be found in the muscles of extensive limb injuries, Prentice and his colleagues did not explain the huge losses of transfused blood which they had demonstrated. This report clearly shows that even massive transfusions of blood may not completely restore a normal circulating blood volume after severe blood loss due to accidental injury. The indirect methods of assessment of blood loss on the basis of the size of the injury and the effects of bleeding on systemic blood pressure and peripheral circulation, combined with repeated observations of the effects of treatment, are probably as effective as more direct measurements and certainly more widely applicable.

The very large transfusions advocated by Prentice and his colleagues are not without the danger of citrate intoxication (see Blood Transfusion, p. 35). Gurd and Gardner (1955) have pointed out that, at least in dogs, 75 per cent of the volume of blood lost can be very rapidly replaced without much danger, but thereafter the rate of replacement should be reduced in order to avoid an undesirable and often fatal rise of venous pressure The apparent rarity of citrate intoxication even after rapid blood transfusion is probably largely due to underestimation of the size of the blood loss and the limited quantity of blood which can usually be obtained. There is at present no good indication for the wider or more lavish use of blood transfusion.

PLASMA SUBSTITUTES

Gelatin and its derivative oxypolygelatin are no longer used because it has been realized that owing to their low molecular weights they are so rapidly excreted in the urine as to be useless for lasting expansion of the intravascular volume. Preparations of polyvinylpyrrolidone also have a limited value for the same reason and are not now in use. Gum acacia is still widely employed especially in tropical countries because of its relative cheapness, but because of its complicated and largely unknown physio-chemical properties gum acacia is unlikely to be developed beyond the empirical preparation which has been of so great a value for the last 40 years. Dextran remains the most useful plasma substitute of recent development and, provided it is suitably fractionated, the substance of greatest potential value.

Especially after the administration of very large volumes of dextran solution, an increase in bleeding time has been reported (Carbone and his colleagues, 1954). This tendency to bleed was at first attributed to some adverse effect of dextran on blood coagulation. Although *in vitro* dextran may alter the rate or completeness of individual stages of the clotting of blood, it seems unlikely that *in vivo* similar effects cause a prolongation of bleeding time, which appears to be related rather to an over-filling of the vessels as the result of the administration of more dextran solution than is needed to restore blood volume.

It was originally believed that the low incidence of reactions of all kinds following the injection of dextran was an important advantage. It was later found that when a dextran solution was injected into volunteers with normal blood volumes the reaction rate rose to 40 per cent (Gropper and his colleagues, 1952) or higher. It was shown independently by Heisto and Lund (1953), and Wilkinson and Storey (1953), that the reaction rate was related to the strain of the bacteria used in the production of dextran, and that the reactions could be divided into two phases, one in which the main feature was an urticaria and the other characterized by profound vasomotor disturbances. Wilkinson (1956c) found that strain was more important than the molecular size of the dextran in causing reactions. Kabat and Berg (1952) had found that the intensity of the antigenic properties of dextran are directly related to molecular weight, and it has been suggested that reduction of the proportion of large molecular weight material in a solution for clinical use will reduce the incidence of reaction. Unfortunately, when the proportion of larger molecular weight dextran is lowered the effect of dextran on blood volume, and its duration, is much less.

It has been established by the use of dextran labelled with ^{14}C that even dextran of high molecular weight can be metabolized in the body and the resulting products excreted. Recovery of over 90 per cent of the ^{14}C administered in combination with dextran was reported by Terry and his colleagues (1953), 25 per cent as carbon dioxide and about 40 per cent in the urine. The work of Terry and his colleagues and of Gray (1953) showed that there was a higher concentration of dextran in the liver, lymph glands, adrenals and spleen than in other tissues. The dextran disappears more rapidly from the liver than from other tissues, but the elimination of ^{14}C as CO_2 continues after dextran has disappeared from the blood. In dogs dextran disappears completely in 5 weeks after the administration of a dose of 1 gramme per kilogram of body weight, equivalent to the administration of more than 1 litre of a 6 per cent solution of dextran to a 70-kilogram adult man These investigations confirm the earlier conclusions of Bull and his colleagues (1949) based on a serological method of detection of dextran.

METABOLIC EFFECTS OF INJURY

In the study of the changes in metabolism which follow severe injury, the emphasis has largely shifted from the details of the alterations in the composition of the urine to the output of adrenal cortical hormones in the urine, and more recently to the concentration of these hormones in the peripheral blood. It must be recognized, however, that agreement has still to be reached regarding what is a normal pattern of urinary composition after severe injury. The early descriptions by Cuthbertson

did not respond well, and that a small proportion of them died. Many surgeons have doubted whether more rapid transfusion of still larger volumes of blood would have saved such men, and the cause of this type of disturbance has remained undecided. The experience of Prentice and his colleagues (1954) in Korea during 1952–53 has provided valuable information regarding the effects of transfusing battle casualties with very large volumes of blood; they measured red cell or plasma volume after injury and at various stages during the treatment of 53 patients, and compared these results with the normal volumes calculated from body weight. They found that the post-operative blood volume was nearer normal in patients with abdominal wounds than in those with wounds of the limbs. After injuries of the limbs, as the total quantity of blood transfused rose so did the difference between the patients' red cell and plasma volumes and the volume transfused. In spite of a measured deficiency in blood volume, compared with the calculated normal, of up to 25 per cent even after transfusions of 20 pints, the general condition of the patients was good Apart from suggesting that much of the apparently lost blood might be found in the muscles of extensive limb injuries, Prentice and his colleagues did not explain the huge losses of transfused blood which they had demonstrated This report clearly shows that even massive transfusions of blood may not completely restore a normal circulating blood volume after severe blood loss due to accidental injury. The indirect methods of assessment of blood loss on the basis of the size of the injury and the effects of bleeding on systemic blood pressure and peripheral circulation, combined with repeated observations of the effects of treatment, are probably as effective as more direct measurements and certainly more widely applicable.

The very large transfusions advocated by Prentice and his colleagues are not without the danger of citrate intoxication (see Blood Transfusion, p. 35). Gurd and Gardner (1955) have pointed out that, at least in dogs, 75 per cent of the volume of blood lost can be very rapidly replaced without much danger, but thereafter the rate of replacement should be reduced in order to avoid an undesirable and often fatal rise of venous pressure. The apparent rarity of citrate intoxication even after rapid blood transfusion is probably largely due to underestimation of the size of the blood loss and the limited quantity of blood which can usually be obtained. There is at present no good indication for the wider or more lavish use of blood transfusion.

PLASMA SUBSTITUTES

Gelatin and its derivative oxypolygelatin are no longer used because it has been realized that owing to their low molecular weights they are so rapidly excreted in the urine as to be useless for lasting expansion of the intravascular volume. Preparations of polyvinylpyrrolidone also have a limited value for the same reason and are not now in use. Gum acacia is still widely employed especially in tropical countries because of its relative cheapness, but because of its complicated and largely unknown physio-chemical properties gum acacia is unlikely to be developed beyond the empirical preparation which has been of so great a value for the last 40 years. Dextran remains the most useful plasma substitute of recent development and, provided it is suitably fractionated, the substance of greatest potential value.

Especially after the administration of very large volumes of dextran solution, an increase in bleeding time has been reported (Carbone and his colleagues, 1954). This tendency to bleed was at first attributed to some adverse effect of dextran on blood coagulation. Although *in vitro* dextran may alter the rate or completeness of individual stages of the clotting of blood, it seems unlikely that *in vivo* similar effects cause a prolongation of bleeding time, which appears to be related rather to an over-filling of the vessels as the result of the administration of more dextran solution than is needed to restore blood volume.

It was originally believed that the low incidence of reactions of all kinds following the injection of dextran was an important advantage. It was later found that when a dextran solution was injected into volunteers with normal blood volumes the reaction rate rose to 40 per cent (Gropper and his colleagues, 1952) or higher. It was shown independently by Heisto and Lund (1953), and Wilkinson and Storey (1953), that the reaction rate was related to the strain of the bacteria used in the production of dextran, and that the reactions could be divided into two phases, one in which the main feature was an urticaria and the other characterized by profound vasomotor disturbances Wilkinson (1956c) found that strain was more important than the molecular size of the dextran in causing reactions Kabat and Berg (1952) had found that the intensity of the antigenic properties of dextran are directly related to molecular weight, and it has been suggested that reduction of the proportion of large molecular weight material in a solution for clinical use will reduce the incidence of reaction Unfortunately, when the proportion of larger molecular weight dextran is lowered the effect of dextran on blood volume, and its duration, is much less

It has been established by the use of dextran labelled with ^{14}C that even dextran of high molecular weight can be metabolized in the body and the resulting products excreted Recovery of over 90 per cent of the ^{14}C administered in combination with dextran was reported by Terry and his colleagues (1953), 25 per cent as carbon dioxide and about 40 per cent in the urine. The work of Terry and his colleagues and of Gray (1953) showed that there was a higher concentration of dextran in the liver, lymph glands, adrenals and spleen than in other tissues. The dextran disappears more rapidly from the liver than from other tissues, but the elimination of ^{14}C as CO_2 continues after dextran has disappeared from the blood In dogs dextran disappears completely in 5 weeks after the administration of a dose of 1 gramme per kilogram of body weight, equivalent to the administration of more than 1 litre of a 6 per cent solution of dextran to a 70-kilogram adult man These investigations confirm the earlier conclusions of Bull and his colleagues (1949) based on a serological method of detection of dextran.

METABOLIC EFFECTS OF INJURY

In the study of the changes in metabolism which follow severe injury, the emphasis has largely shifted from the details of the alterations in the composition of the [illegible]

of urinary composition after severe injury. The early descriptions by Cuthbertson

(1936) of the effects of severe injury concerned patients with fractures who did not receive any intravenous infusions and who were not transfused with blood. Most reports which have since appeared have been of changes observed in patients to whom varying quantities of water and minerals were given by intravenous infusion. The response of the whole organism to injury is a phenomenon which is found in all forms of life and is essential to survival. If the limitations as well as the advantages of this response are to be understood it should be studied in man in as pure a form as possible, with as few distortions due to treatment as are consistent with survival and comfort It has been argued that by stopping the intake of water for 48 hours and of food for 4 days the effects of injury are lost amidst those due to starvation. There are, however, marked differences between the pattern of urinary composition during starvation and after operation with similar starvation (Wilkinson, 1956b). The difference between the effects of operation and starvation, and operation combined with the intravenous administration of moderate volumes of glucose solution or 0·9 per cent saline are not very great When very large volumes of water (4 litres per day) are administered or consumed, the so-called normal urinary pattern is considerably altered (Le Quesne and Lewis, 1953); oliguria lasts only 24 or 48 hours, sodium conservation may last only 24 hours, but the loss of potassium may be increased Flear and Clarke (1955) found that they were able to modify the metabolic effects of severe accidental injury by the transfusion of very large quantities of blood, and they concluded that blood loss and reduction of the volume of blood in active circulation were the most important factors in causing the whole body metabolic response to injury. This conclusion does not accord well with evidence obtained from patients submitted to operations such as partial gastrectomy with measured external blood loss of less than 200 millilitres, in whom the disturbance of the whole body seems to be related more to the shifts of body fluids associated with the production of a dynamic inflammatory exudate in the injured tissues than to reduction in blood volume alone.

Much has been written about the changes in the composition of the blood which have been observed after major operations on patients to whom fluid is administered by intravenous infusion One change in particular, the reduction in serum sodium concentration at a time when the kidneys are conserving sodium and the total body content of sodium is increasing, the so-called "sodium paradox", has given rise to much discussion When water intake is stopped for 48 hours after operation both the packed cell volume and the serum sodium concentration rise indicating an extracellular dehydration; there is also a very large loss of body weight during the first 2 or 3 days, a loss which is greater than that found in unoperated controls subjected to the same restrictions of water and food intake. It seems likely that the reduction in sodium concentration which is so common in association with intravenous infusions is due to the retention of an excessive quantity of water in the extracellular phase, with consequent dilution of the extracellular sodium. This point of view receives some support from the increase or only small reductions in weight exhibited by such patients and by the failure of intravenous infusions to relieve the severe thirst which is so troublesome during the first 48 hours after operation.

Ingle (1952) and Engel (1951) pointed out that the adrenalectomized rat main-

tained on a steady dose of cortical extract still produced a normal increase in nitrogen output after injury, and they suggested, therefore, that an increased adrenal steroid production may not be essential for the development of a "normal" metabolic response to injury. They believed rather that some other as yet unknown factor initiates the response to injury, but that the full development of this response requires the production of sufficient cortical hormone. Because Steenburg and Gannong (1955) found that there was an increase in corticoid production after anaesthesia and operation on adrenalectomized dogs maintained on a constant dose of cortisone, it has been assumed that the hypothesis of Ingle and Engel must be wrong, if it presupposes that on a constant maintenance dose of cortisone the blood corticoid concentration also will remain constant. This view possibly gives too little weight to variations in the rate of conjugation or metabolism of corticoid hormones, and lays too much emphasis on the measurements of the blood concentration and urinary excretions. Neither of these estimations is yet so reliable that more than tentative conclusions may be drawn and the urinary excretion provides information of the fate of only a very small fraction, perhaps 5 per cent, of the total production. Nevertheless, the timing, magnitude and shape of the curve of the blood concentration of 17-hydroxycorticoid which Steenburg and his colleagues described justifies their conclusion that this hormone complex is of primary importance in the production of the post-operative changes in body composition and metabolism.

There is a broad general relationship between the severity of an injury and the quantities of nitrogen and 17-hydroxycorticoid hormone or derivatives excreted in the urine, but the large variations between individuals and related to different kinds of injury, such as deliberate abdominal operation or accidental fractures, require a cautious approach to the interpretation of the results of observations on injured animals and patients. The output of corticoid substances in the urine may be affected by changes in the rate of production of the hormones in the adrenal gland, of conjugation with glucuronic acid in the liver, or of excretion in the urine. Most of the 17-hydroxycorticoid excreted in the urine has been conjugated and is inactive. The action of the hormone on tissue appears to be related to its concentration in the extracellular fluid and measurement of changes in the blood concentration may give a better idea of the effects of injury than the excretion of largely inactive conjugates In patients submitted to abdominal operation Steenburg, Lennihan and Moore (1956) found that the free serum 17-hydroxycorticoid concentration rose steeply after operation to reach a peak often within a few hours and then fell sharply again and reached a normal concentration within 48 hours of operation They did not find any relationship between the serum concentration and the quantity which was excreted in the urine. The sudden and early rise in serum concentration might be due to an equally sudden increase in adrenal activity or decrease in the rate of conjugation or tissue utilization; it coincides with the rise in potassium excretion and the fall in eosinophils but precedes the rise in nitrogen excretion, and is unrelated to the variable time of onset of sodium conservation. The importance of altered liver function has been emphasized by Samuels and his group (Tyler and his colleagues, 1954; Eik-nes and his colleagues, 1955) who found very similar changes in serum concentration after operation. They have also shown that the magnitude of the rise in serum corticoid concentra-

tion was related to the severity of impairment of liver function, as was the rate of removal of infused 17-hydroxycorticoid.

Bernhard and McMurrey (1955) found that in dogs hypothermia leads to a reduction in adrenal blood flow and the output of 17-hydroxycorticoid which with corticoid output returns promptly to normal on re-warming. Surgical injury or the injection of ACTH do not alter the low blood flow. When shock is induced in dogs by bleeding, the adrenal venous blood flow falls, but the total output of corticoid hormone is maintained. Bernhard and McMurrey also found that blood corticoid concentration tended to rise slightly in hypothermic dogs with or without exclusion of the liver from the circulation. It seems evident that the marked reduction in adrenal corticoid production is more than balanced by a reduction in the rate of conjugation in the liver, excretion in the urine or oxidation in the tissues. They found a much smaller increase in corticoid production by hypothermic patients compared with the high initial peak (4–6 times the initial value) described at normal temperatures by Steenburg and his colleagues (1956). In cooled patients there was only a small corticoid response to anaesthesia and no further rise in spite of severe surgical injury, except in one patient with severe liver damage who showed a late but prolonged rise in blood corticoid concentration.

When, after bilateral adrenalectomy, the patient is maintained with adequate doses of cortisone, there is still some increase in the urinary excretion of potassium and nitrogen, and a decrease in the urinary excretion of sodium (Robson and his colleagues, 1956, Wilkinson, 1956a) in the pattern characteristic of the metabolic response to operative injury in patients with intact adrenal glands. In the patient after adrenalectomy such changes are not accompanied by an increase in the urinary output of adrenal cortical hormones (Mason, 1955) It has therefore been argued that the adrenal cortical hormones are not essential for the production of the normal metabolic response to injury, but this ignores the fact that the patients on whom these observations were made were maintained with adequate doses of cortisone on which survival appears largely to depend; attempts to maintain patients immediately after bilateral adrenalectomy with prednisone or prednisolone have not been successful (Wilkinson, 1957). There is evidence that the production of aldosterone ceases after bilateral adrenalectomy (Dudley and his colleagues, 1957; Wilkinson, 1957), and Dudley and his colleagues (1957) have suggested that the normal metabolic response can occur without any rise in the excretion of aldosterone, provided substitution therapy (cortisone) is adequate.

In the present confusion all that is certain is that survival from injury and severe infection depends on satisfactory adrenal function or adequate substitution therapy. It seems rather unlikely that more precise definition of the relative degrees of importance of the three dozen or so adrenal cortical hormones will be achieved quickly in spite of the vast amount of effort at present being expended on such studies.

Aldosterone

In 1952 aldosterone (18 aldo-corticosterone) was isolated from beef adrenal tissue by Simpson and his colleagues (1954) It was shown to be identical with the

sodium retaining corticoid which had been described in 1950 by Luetscher and Johnson. The distribution of this hormone in the blood, urine and adrenal glands of normal and diseased patients, and its biological effects have since been intensively studied. The concentration of aldosterone in blood and the quantity excreted in the urine are very small compared with other adrenal cortical hormones, but although aldosterone exerts little effect on carbohydrate or protein metabolism (Prunty, McSwiney and Mills, 1955), its action on sodium and potassium metabolism is about 30 times as great as that of desoxycorticosterone (Zimmerman and his colleagues, 1955). Like desoxycorticosterone, aldosterone causes an almost immediate increase in potassium excretion in the urine and a rather slower reduction in sodium excretion These changes in urinary composition are probably only reflections of widespread alterations in cellular composition based on the exchange of extracellular sodium and hydrogen ion for intracellular potassium. It is still uncertain which is the primary disturbance, but the onset of potassium diuresis before there is a measurable alteration in sodium excretion in the urine suggests that the primary alteration is probably in the cellular content of potassium. After injury or operation the urinary output of aldosterone rises, but there is much individual variation both in the pre-operative daily output and the magnitude of any increase The cause of this increase is unknown, but it has been suggested that it may be due largely to the restriction of sodium intake, an explanation which is difficult to reconcile with the retention of sodium which occurs when the sodium intake is maintained unchanged throughout the post-operative period, or with the occasional onset of sodium retention before operation; moreover, following the complete stoppage of the intake of both food and water, sodium excretion may not fall for more than 24 hours and potassium excretion may continue unchanged. Laragh and Stoerk (1955) found that the consumption of excessive quantities of potassium increased the urinary output of aldosterone, but changes in serum sodium concentration were not associated with any alterations in output of the hormone Unlike most others, they have suggested therefore that potassium has a more powerful and direct influence than sodium on the rate of production of aldosterone, and on teleological grounds there is a good deal of support for their view Bartter (1956) has shown that the output of aldosterone is independent of the total body content of sodium and of the sodium concentration in extracellular fluid, but related to changes in the volume of extracellular fluid. Volume for volume reduction of the total body water has less effect in reducing aldosterone excretion than the reduction in extracellular fluid which follows the increased sodium and water excretion induced by mercurial diuretics.

The output of aldosterone is raised in association with hepatic cirrhosis, nephrosis and cardiac failure and in eclampsia and Cushing's disease (Luetscher and Johnson, 1954). The oxidation or conjugation of aldosterone may be altered in [illegible]

ascites or oedema In nephritis a secondary rise in aldosterone secretion may be due to the urinary loss of sodium and water due to defective renal tubular function.

In 1955 Conn described "primary aldosteronism" a syndrome due to an adrenal tumour which produced large quantities of aldosterone; less than a dozen examples

of this disturbance have been described (Milne, Muehrcke and Aird, 1957). It may be characterized by hypertension, tetany, flaccid paralysis and polyuria, or the clinical disturbance may be slight or absent; there is marked reduction (up to 1,000 milli-equivalents) in the body content of potassium, and alkalosis Chemical examination of muscle shows a reduction in potassium and an increase in sodium content. The urine is alkaline or neutral in reaction and contains little sodium, as in patients with pyloric stenosis. When the large deficiency of potassium is replaced the urinary output of sodium rises and the urine becomes strongly acid The urinary outputs of aldosterone and of potassium are high and this, in the absence of oedema or severe cardiac or renal disease, together with the combination of hypertension, potassium depletion and alkalosis, should suggest the diagnosis

SODIUM AND POTASSIUM

The convenience of the flame photometer has led to a wider curiosity about the serum concentrations of sodium and potassium, but the difficulties of correct interpretation are often not suspected and seldom properly appreciated. Too little is known of the complicated pathological possibilities which are inherent in changes in content as well as distribution of sodium, potassium and water in the body for complete understanding of more than a part of the whole field. It is equally important to recognize that changes in the extracellular concentration of sodium and potassium may have many explanations and that isolated measurements are seldom of much value.

A low serum sodium concentration may be due to the loss of sodium from the body or to an increase in water content without change in total sodium. Sodium loss occurs most often by vomiting, diarrhoea or from fistulas of the gastro-intestinal tract, and dilution of the sodium remaining in the body is due to the administration of an excessive quantity of water. In severe potassium depletion the shift of sodium and hydrogen ions into the cells to replace some of the lost potassium alters the distribution but not the total content of sodium in the body; when the potassium is replaced the transfer of this sodium back into the extracellular fluid may be accompanied by an increase in the volume and the sodium concentration of the extracellular fluid. In cardiac disease with oedema the total body content of sodium is above normal whatever the serum sodium concentration may be, and when the concentration is low this is usually because of water retention; the administration of sodium to such patients does them harm. When it is known that sodium and water have been lost and the serum sodium concentration is low, improvement follows the administration of suitable solutions of sodium salts. When the serum sodium concentration is low because of the excessive administration or ingestion of water, the water intake should be restricted; in some patients recovery can be accelerated by the injection of a hypertonic solution of sodium chloride (5·58 per cent containing 1 milliequivalent sodium per millilitre)

The importance of the skeleton as a reservoir for the mineral constituents of the body is now becoming more evident. The enormous surface area of the crystals in bone (Robinson, 1951) provides an extensive site for the adsorption of sodium, potassium and magnesium in an ideal situation for a dynamic equilibrium with the

surrounding extracellular fluid. In experimental animals much of the exchangeable sodium in bone can be removed in a few hours in suitable conditions such as artificially induced severe acidosis, and similar large shifts of sodium may occur also in human beings. Decalcification of bone in chronic renal acidosis and in lactation are well-known examples of the lability of at least part of the mineral content of human bones (Owen, 1952). There is no evidence, however, that the bones can act as a storage site for minerals in the sense that an excess can be deposited above the normal content.

So far direct measurements of changes in bone sodium in disease have not been made in human patients, but there is evidence from animal experiments of loss of sodium from bone in acute sodium deficiency and in adrenal hypofunction, and it is believed that similar losses might occur in patients and also after sodium losses by diarrhoea, excessive sweating, diabetic acidosis, or prolonged restriction of sodium intake or the use of mercurial diuretics. The part played by bone sodium in the production of a low serum concentration of sodium must remain uncertain until more accurate measurements of changes in the content and distribution of water as well as of sodium are possible.

The interpretation of the serum concentration of potassium also depends on consideration of the daily intake and output of potassium and the type of any change in distribution of potassium within the body. In anuria there may be almost no change at all in the total body content of potassium, but the steady increase in the serum or extracellular concentration of potassium indicates the altered distribution of a small fraction of the total content. It is not uncommon for the serum potassium concentration to fall well below the normal range in patients who are being treated with adrenal cortical hormones, without any functional evidence of potassium depletion; this type of disturbance appears to be due to the rate of excretion in the urine exceeding the rate at which potassium is mobilized from the cells. The total potassium content of a 70-kilogram adult man is about 3,400 milliequivalents, of which only 60 milliequivalents are in the extracellular fluid and about 15 milliequivalents in the 3 litres or so of plasma. Severe disturbance of myocardial function is common at extracellular potassium concentrations of 7·5 milliequivalents per litre which may result from the altered distribution of 30 milliequivalents of potassium, less than 1 per cent of the total body content. Apart from the intake of potassium the extracellular content depends on the balance between transfer out of cells and excretion in the urine, and extracellular concentration also depends largely on the same factors, being comparatively little affected by changes in the volume of the extracellular fluid. It is now evident that the discovery of a low serum concentration of potassium does not itself justify a diagnosis of potassium deficiency In addition to repeating the measurement of serum concentration, the daily intake and urinary excretion of potassium must be measured, and it is usually helpful to measure also the sodium and water exchanges A history of the chronic loss of body fluid, for example, due to repeated vomiting or diarrhoea, or of starvation, will also help to interpret the serum level correctly Finally, when facilities exist the total body content of potassium may be measured by the isotope dilution method. By these means it has been found that in chronic malnutrition and in prolonged pyloric stenosis losses of up to 1,000 milliequivalents of potassium, one-third of the normal healthy

content, are not uncommon and are not always accompanied by a low serum potassium concentration (Wilkinson, 1957).

RENAL FAILURE AND ANURIA

The better understanding of the morbid anatomy and the resulting renal functional disturbances and biochemical effects has led to an improvement in the prognosis for anuric patients, and there is now a tendency to employ more moderate measures in their management. It is becoming evident that a proportion of patients will recover rapidly provided that during the anuric stage their fluid intake is restricted to a volume sufficient to provide for insensible water loss, the intake of protein, sodium and potassium is stopped, but the consumption of some fat and carbohydrate is maintained. These objectives can be achieved as well by a suitably modified diet (Folin, 1905) as by the intragastric infusion of an emulsion of vegetable oil and glucose. Of the remaining patients some will die no matter what may be done for them, but unfortunately it seems impossible to distinguish between these patients with irrecoverable renal lesions and the remainder who will survive if they can be kept alive until sufficient renal function returns During the first 10–14 days, elevation of the potassium concentration of the extracellular fluid with disturbance of cardiac function has appeared to be the commonest cause of death. Treatment, therefore, has been concentrated on attempts to reduce first the transfer of potassium from intracellular to extracellular fluid, and secondly the quantity of potassium in the extracellular fluid. In patients with severe injuries katabolism of protein in the damaged tissue is inevitable; in normal tissue it may be aggravated by starvation and in both types it leads to the release of intracellular potassium as well as of phosphate, sulphate and protein residues; similarly, potassium is released from the involuting uterus after abortion or intrauterine haemorrhage. Apart from sound and early surgical treatment of the wounds a the prevention of infection with its accompanying increment of protein katabolisı there is little that can be done to minimize this mobilization of intracelluḷ potassium. When restriction of water intake is too severe the mobilization c intracellular water may increase the extracellular content of potassium. In rena failure potassium intoxication is seldom now due to any increase in the total body content of potassium caused by the continued administration of potassium salts, it is rather the result of a change in the distribution of potassium between intracellular and extracellular fluid. This change is not due simply to the shift of water and potassium out of cells because of intracellular dehydration due to an inadequate water intake, nor does it seem always to be due to the mobilization of potassium following either severe accidental or surgical tissue injury, or abortion, or intrauterine bleeding. The need to buffer retained acid may lead to the exchange of hydrogen ions from the extracellular fluid for intracellular sodium and potassium ions with a consequent increase in extracellular potassium concentration (Swan and Merrill, 1953; Schwartz, 1955). The sudden death associated with a raised extracellular potassium concentration is due to disturbance of cardiac function by complex chemical changes in the composition of cardiac muscle and its environmental fluid, and of these a shift of potassium is only one It is for this reason that the electrocardiographic tracing often gives the best indication of an impending cardiac disturbance, because here, as in citrate intoxication, it describes

total function rather than an individual component, potassium or citrate, of a set of complicated alterations in both distribution and concentration.

It has been claimed that up to 75 milliequivalents of potassium may be extracted daily from the extracellular fluid by the use of a suitable ion exchange resin; 15 grammes of a sulphonic resin charged with ammonium mixed with syrup or water may be swallowed or instilled by tube into the stomach 3 or 4 times a day; the resin should remain in contact with the gastro-intestinal mucosa for at least 12 hours for it to be fully effective (Evans and her colleagues, 1953). The resin should be given as soon as the serum potassium concentration exceeds 6 milliequivalents per litre. It seems likely that wider use may be made of the principle of dialysis with the artificial kidney; a portable and expendable dialysis apparatus is now available with which, for the cost of the expendable part and a small outlay on a suitable bath, pump and thermostatic control, satisfactory results have been obtained. Unless facilities for careful clinical control and reliable biochemical assistance are available throughout the 24 hours, attempts to use the artificial kidney are not justified. The preponderance of poor results make it a procedure for enthusiasts alone. The provision of calories and a limited volume of water by the infusion of a 50 per cent solution of glucose into the inferior vena cava has been frequently recommended in the treatment of renal failure and anuria. This method is not free from risk and should be reserved for those patients in whom oral feeding is impossible because of intractable vomiting. Chambers and Smith (1957) found it necessary to employ caval infusion in only 8 of 29 patients with acute renal failure of whom 4 died, but in none was death related to the infusion nor did they believe that any of these patients would have survived if dialysed on an artificial kidney. They recommended that a nylon catheter (size 9F) should be inserted through the upper end of the internal saphenous vein into the superficial femoral vein and pushed on into the inferior vena cava until the tip is above the level of the renal vein; they administered 700 millilitres of 50 per cent glucose solution per day providing 1,300 calories.

During the early diuretic phase of recovery from anuria much emphasis has been placed on the complete replacement of all the sodium excreted in the urine. A large sodium output may be partly and even largely due to the excretion of a large quantity retained in the earlier stage of oliguria or anuria. Complete replacement for a number of days simply perpetuates artificially the abnormally large body content of sodium and water, a chronic expansion of the extracellular fluid volume. Treatment must be guided by repeated clinical observation at least as much as by chemical measurements of urinary excretion.

In renal failure the change in carbon dioxide combining power is an indication of a change to modify a tendency to acidosis or alkalosis; in other words, the change in pH is resisted by the alteration in carbon dioxide combining power. Treatment must be designed not to raise or lower the alkali reserve, for example, by giving sodium bicarbonate or sodium lactate in the acidosis of renal failure, but rather to correct the underl[illegible]
most ofte[illegible]
and wher[illegible]
depletion [illegible]
fusion of sodium lactate is seldom followed by improvement.

TRANSPLANTATION OF THE URETERS

Evidence has accumulated that the most important factor in causing biochemical disturbances after this operation is the length of time for which urine remains in contact with the intestinal mucosa. In the hope of avoiding acidosis and ascending renal infection the ureters have been transplanted into an isolated loop of small intestine, and it has been found that although infection then becomes a negligible factor, if the intestinal loop is sufficiently long or is not emptied of urine often enough, hyperchloraemic acidosis will still develop. The use of a short ileal loop which discharges urine freely into a suitable bag is a marked improvement on diversion of the urine to the colon, but a small risk of biochemical disturbance still remains.

NECROTIZING ENTERITIS

This severe and often fatal complication of operations, especially those on the upper gastro-intestinal tract, may cause an acute diarrhoea of choleraic severity (Pullan, 1955) In the most severe form it is seldom possible to stop the diarrhoeal discharge even with very large doses of opium, and it is always difficult to maintain by intravenous infusion a sufficiently rapid replacement of the fluid lost in the stools. While there is not much doubt regarding the principles by which treatment must be directed, their application to the individual patient is always difficult and complex. Two rectal smears should at once be taken and while a Gram-stained preparation of one is examined in the ward the other should be given to the bacteriologist; if gram-positive cocci are found intensive treatment must immediately be started. Existing antibiotic therapy should be stopped and instead erythromycin should be given by mouth or by stomach tube if there is vomiting. Survival depends on the maintenance of an adequate volume of blood in active circulation. Although dextran might seem to be the obvious first choice for this purpose, in a prostrated patient with empty firmly constricted veins it may be better to start to replace the huge acute loss of fluid as Latta did by the very rapid infusion of 0 9 per cent saline solution, which being much less viscous than dextran can be more readily injected at a very rapid rate, and after opening the superficial veins by the injection of 2 litres of saline solution to continue with 1 litre of 6 per cent dextran in saline solution When sufficient saline solution and dextran has been injected to stabilize the general state of the patient, which may amount to 4 or 5 litres in an hour, the rate of infusion can be reduced and Darrow's solution can be used to reduce the accompanying acidosis Unless the patient is drinking up to 1 litre of water, 6 per cent glucose solution also should be infused in each 24-hour period. Less severe but often troublesome degrees of diarrhoea are not uncommon amongst surgical patients, and may cause acute reduction of extracellular fluid volume; they too should be treated by the rapid infusion of 0 9 per cent saline solution combined with the oral consumption of tincture of opium and kaolin.

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THE STOMACH AND DUODENUM

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Although there has been no great advance in the knowledge of diseases of the stomach and duodenum in the last year or two there has, nevertheless, been steady progress in certain fields.

ABO BLOOD GROUPS

In 1953 Aird, Bentall and Roberts showed that amongst patients with carcinoma of the stomach there is an excess of those with blood-group A over those with blood-group O when compared with controls from the same areas. This relationship has since been confirmed in other parts of the world. It seems also to be established that this difference is largely due to an increase in the frequency of carcinoma of the pyloric part of the stomach in people of group A (Billington, 1956; Jennings, Balme and Richardson, 1956; Turunen and Pasila, 1957). Koster, Sindrup and Sele (1955) found a very high incidence of blood-group A among patients with achlorhydria but were unable to find an excess of group A in a series of patients with pernicious anaemia. Such a relationship between pernicious anaemia and group A has, however, been found in a series of patients collected in Great Britain (Aird and his colleagues, 1956). In view of the lack of excess of group A in cases with carcinoma of the body of the stomach, Billington considered that the gastric mucous secretion may be of more importance in the aetiology of carcinoma of the stomach than acid secretion and he suggested that group O may give protection to the pyloric mucosa from carcinogenic factors. As will be discussed below, blood-group substances are often present in saliva and gastric secretions.

[illegible] shown by Aird and [illegible] been shown by Clarke and his colleagues (1955) to be due to an excess of group O in patients with duodenal ulcer, the ABO distribution being normal in patients with gastric ulcer.

It has been known for many years that certain people secrete in their tissue fluids substances similar to, or identical with, their blood-group substances

(Morgan, 1944). Not all people do, in fact, secrete these substances, those who do being known as secretors and those who do not, non-secretors. Those who do secrete and who belong to groups A and B secrete the specific substance for their group, those of group AB secreting both substances Those of group O secrete a substance H, which may also be found in secretors of groups A, B and AB. These substances are by nature muco-polysaccharides.

Clarke and his colleagues (1956) tested for the presence of these group substances in the saliva of patients with duodenal ulcer and in controls and found there was a significantly higher proportion of non-secretors in the duodenal ulcer patients (35 per cent) than in the controls (24·2 per cent). They put forward the suggestion that these substances may protect against duodenal ulceration by virtue of their mucoid character.

The work in this field has become very complex but shows considerable promise that it will in time be able to throw much light on the aetiology of carcinoma of the stomach and peptic ulcer.

ACUTE PANCREATITIS FOLLOWING GASTRECTOMY

It is common knowledge that acute pancreatitis may follow operations on the biliary system and on the pancreas itself; it appears to be less well known that this complication may follow partial gastrectomy and even operation in the lower abdomen Burton, Eckman and Haxo (1957) described 12 cases of acute pancreatitis, 5 of which were fatal, in 348 gastrectomies That this is an unusually high incidence is shown by Viikari and Klossner (1957) who had no pancreatic complication in 1,050 gastrectomies. A further case has been recorded by Stuart and Jordan (1957) Frieden (1956) has given an account of 22 fatal cases of acute pancreatitis; 9 of these followed operations on the biliary system and the pancreas, 9 followed gastric operations and 4 followed operations in which there was no apparent trauma to the pancreas

It is also known that disturbances of pancreatic function, as judged by urinary diastase and serum amylase estimations, without symptoms or clinical signs, are present in a proportion of patients after partial gastrectomy. The present writer found high post-operative urinary diastase levels in 5 patients in a series of 50 partial gastrectomies Millbourn (1949) in a series of 149 gastric resections found very high urinary diastase levels in 13 patients; 7 of these had symptoms and 2 died.

Factors causing disturbances

Many explanations have been put forward to account for these disturbances, direct trauma and vascular injuries being the most obvious. Lesions of the pancreatic drainage system have also been incriminated The accessory pancreatic duct of Santorini is the sole or chief channel of excretion in 10 per cent of patients (Opie, 1903; Millbourn, 1949). This duct enters the duodenum 3–5 centimetres from the pylorus and it is therefore vulnerable during mobilization of the duodenum especially when this is shortened by fibrosis Although it has been established that experimental ligation of the pancreatic duct does not lead to the development of pancreatitis it is reasonable to assume that ligation of the main excretion channel in association with mechanical or vascular trauma to the pancreas may lead to the

liberation and activation of ferments in the organ. Division without ligation of such a duct will lead to the outpouring of enzymes into the peritoneal cavity or the formation of an external pancreatic fistula.

It is obvious that other than local factors may be responsible in many cases as the complication has been described following operations such as sigmoid colostomy, herniorrhaphy and perurethral resection of the prostate but its higher incidence after biliary, pancreatic and gastric operations shows that local factors are of considerable importance in its aetiology.

Pancreatitis is a rare complication of gastrectomy when a careful technique is adopted but the fact that it does occur emphasizes the need to avoid trauma to the pancreas as far as possible and to bear in mind the relative proximity to the pylorus of the duct of Santorini, which may be the chief channel of excretion from the organ.

PERFORATED PEPTIC ULCER

The mortality rate of perforated peptic ulcer is in the region of 10 per cent in the larger centres but may well be higher in the country as a whole. Even in the same centre the figure may fluctuate a good deal For example, Avery Jones (1957) reported that in 1947–49 he had an over-all mortality of 8·8 per cent for 182 cases, of whom 168 were operated upon with a mortality of 2·4 per cent: in 1953–55 the corresponding figures for almost exactly the same number of patients were 14·2 and 7·7 per cent. The mortality rises steeply with the age of the patient. *Gilmour* (1953), whose operative mortality was 6·3 per cent, found that this rose from 1 per cent for those under 40 years of age to 18 per cent for those over 60 years of age. The mortality is higher for a gastric than for a duodenal ulcer perforation (Gilmour, 1953; Desmond and Seargeant, 1957).

When the ulcer itself is considered further important points emerge. *Gilmour*, whose patients were treated by simple suture, found that none of the 119 patients with an acute ulcer died whereas 13 of 87 patients with a chronic ulcer died and this group mortality of 15 per cent was responsible for all the deaths in the series Furthermore, on studying the subsequent fate of 181 patients he found that of those with an acute ulcer less than 25 per cent relapsed whereas all 65 patients with a chronic ulcer relapsed, 41 of them needing further surgical treatment. These figures are in accord with those of Illingworth, Scott and Jamieson (1946) who found that after 5 years 70 per cent of patients had relapsed, 50 per cent severely. It is clear that the chronic ulcer which perforates carries a higher initial mortality and a much higher relapse rate than the acute ulcer.

In 1952 Lowdon reported 51 patients with perforated peptic ulcer treated by primary partial gastrectomy without a death and he remarked that their post-operative progress compared favourably with that of similar cases treated by

TABLE I

	Number	*Deaths*	*Mortality*
Suture	365	18	4·9 per cent
Partial gastrectomy	87	4	4·6 per cent

simple suture. In his series there were 46 duodenal and 5 gastric ulcers, a number of which were acute or subacute in nature.

In recent years there has been an increasing tendency to perform partial gastrectomy for a chronic ulcer perforation. Avery Jones (1957) stated that resection had been performed particularly when there had been a history of ulcer symptoms for more than 2 years and especially for perforated gastric ulcer, as an earlier analysis (Avery Jones and Doll, 1953) had shown that 10 per cent of assumed simple gastric ulcers were found to be neoplastic at operation. His figures since 1949 are shown in Table I

Desmond and Seargeant (1957) have given an account of 2 series of patients treated for perforated peptic ulcer at St James' Hospital, Balham. The first, from 1946–52, comprised 208 patients treated by simple suture with a mortality of 9·4 per cent, the figures for duodenal and gastric ulcer respectively being 5 8 and 21 per cent In 1953 they decided to perform partial gastrectomy on all cases of perforated gastric ulcer unless there was some strong medical contra-indication, on perforated duodenal ulcer patients over the age of 40 years with a history of at least 6 months' dyspepsia, on perforated duodenal ulcer patients under the age of 40 years with at least 12 months' history, and on other cases of duodenal ulcer when the ulcer was found at operation to be a chronic one. In the period 1953–56 there were 114 patients after excluding those with a stomal ulcer, those associated with haemorrhage and those moribund. Of the ulcers, 108 were duodenal. Their figures are shown in Table II.

TABLE II

	Number	*Deaths*	*Mortality*
Suture	52	7	14 per cent
Partial gastrectomy	62	2	3 4 per cent

They pointed out that the high mortality in those treated by suture was due to the fact that all who died were so treated because age and infirmity contra-indicated the more severe operation. They also stated that the figures have been influenced in favour of resection by the fact that of those patients over 60 years of age only 30 per cent underwent resection. Their over-all mortality was 8 2 per cent which compares favourably with their 1946–52 series. The mortality rates for those treated within 12 hours of perforation were, for suture 7·3 per cent, for resection 1 8 per cent. Half the survivors following simple suture in both series have already required further surgical treatment.

These papers confirm that the correct treatment for a perforated acute duodenal ulcer is simple suture from the points of view both of immediate mortality and of the long-term comfort of the patient, bearing in mind that in such cases the aspiration treatment described by Taylor (1951) may also give good results It may be that resection should be performed for the perforated acute gastric ulcer, but this does not seem to have been established and study of further series will be necessary to decide this point With regard to the chronic ulcer, so recognized from the length of history and the operative appearances, a case has been made out for primary

gastrectomy, as it does not seem that this will increase the immediate mortality and it will certainly largely abolish the late morbidity associated with simple suture in such patients. It must, however, be stressed, as has been pointed out by the authors quoted, that primary resection should be undertaken only where there is skilled anaesthetic and nursing help available and performed only by those experienced in gastric surgery whose mortality rate for elective gastrectomy is low.

GASTRO-DUODENAL HAEMORRHAGE

In considering the place of surgery in the treatment of haematemesis and melaena it is necessary to bear in mind the very good results of modern medical treatment for this condition. The mortality rate of patients treated medically is under 10 per cent, but it is true to say that a proportion of these could be saved by surgery; it is also true that to treat all patients with gastro-duodenal haemorrhage by surgical methods would be disastrous.

The problem is really that of haemorrhage due to peptic ulceration and gastritis, as this group forms 90 per cent of the total (Tanner, 1951; Avery Jones, 1957). Avery Jones found the mortality rates due to bleeding from chronic gastric ulcer, duodenal ulcer and acute lesions to be 16, 8 and 2·5 per cent respectively. The mortality rate increases with the age of the patient and this is especially so after 60 years when the rates for chronic gastric ulcer and duodenal ulcer are over 21 per cent and that for the acute group has risen to 6 per cent. The recurrence of bleeding after admission to hospital is of serious prognostic significance and the figures of Avery Jones (1956) illustrate this (Table III).

TABLE III

MORTALITY OF PATIENTS WHO BLEED AFTER ADMISSION

	Chronic gastric ulcer	*Duodenal ulcer*	*Acute lesions*
Under 60 years	13 0 per cent	7 0 per cent	1 9 per cent
Over 60 years	42 9 per cent	44 0 per cent	22·5 per cent

There are 3 ways in which surgery may be used in the treatment of this condition.

(1) Operation may be requested when medical treatment has failed and the patient seems doomed This will mean operating on very bad-risk patients but it will undoubtedly save some lives. The resulting high operative mortality does not in itself matter as the important consideration is the over-all mortality, that is, the number of patients who leave hospital alive, a point stressed by Tanner (1950). It is clear, however, that under this regime patients will die who could have been saved by earlier operation.

(2) The second approach is that of Finsterer (1939) who advocated partial gastrectomy within 48 hours for patients with haemorrhage due to a chronic peptic ulcer, and laparotomy for any other patients who continued to bleed; he reported 71 gastric resections with 3 deaths. Tanner (1950, 1951) has given an account of 215 patients treated according to the Finsterer method; 59 per cent were

operated upon with an over-all mortality for the series of 7·5 per cent. Stewart, Cosgriff and Gray (1956) reported 193 patients with massive haemorrhage due to peptic ulcer submitted to early operation, their definition of massive haemorrhage being a measured total red cell mass of less than 60 per cent of the expected normal, 186 gastric resections were performed, the over-all mortality being 13 per cent.

(3) The third method is that of selective surgical intervention, that is, an *early* decision to operate on those patients who are considered to run a high risk of dying from their haemorrhage. The factors to consider here are the presence of a chronic ulcer, particularly a gastric one, increasing age and recurrence of bleeding

It is probable that this third policy will prove to be the right one. Avery Jones (1947) has stated that of his first 400 patients operation was performed on only 3. He has, since 1946, followed a policy of selective surgery, so that in the period 1947–54 approximately 10 per cent of his patients in the peptic ulcer group were operated upon (Avery Jones, 1956) He advised operation on those with severe, continued or recurrent bleeding after admission, particularly if the history suggests a chronic ulcer, and with a preference for those between 40 and 70 years of age. He found that operation may be advisable on patients with a chronic gastric ulcer without recurrent or continued bleeding if they are poor-risk patients who might not be able to withstand further haemorrhage. Those with a short or absent history of dyspepsia are gastroscoped; if bleeding recurs and if shock recurs twice in these patients thought to have an acute lesion operation is advised (Avery Jones, 1957) Tanner (1951) has found that gastroscopy has enabled him to make a certain diagnosis of the cause of bleeding in 90 per cent of his cases. He has also found that emergency gastroscopy may help to decide whether operation should be performed Bowers and Gompertz (1957) have given an account of 434 patients treated for bleeding peptic ulcer. They favoured a conservative regime and performed emergency operations on only 20 patients (5 per cent), making a decision to operate within 48 hours when possible They selected for operation those with a known gastric ulcer, some patients with massive haemorrhage if aged and those who continued to bleed They performed elective operations after the acute phase on 125 patients, the over-all mortality for the series being 3·9 per cent

When a peptic ulcer is found at operation partial gastrectomy should be performed. When a penetrating posterior duodenal ulcer is found it is the practice of some surgeons to divide and close the duodenum proximal to the ulcer. This is very commonly done in elective operations but, when it is performed for haemorrhage, some of the cases will continue to bleed and may require further operation In operations for haemorrhage it is necessary to exclude the ulcer base from the alimentary tract and to control the bleeding with underrunning sutures.

There is still controversy as to what should be done when no ulcer can be found on careful examination of both surfaces of the stomach and duodenum. The performance, in these cases, of a "blind gastrectomy" is advocated by many but with this operation it is possible to miss a shallow ulcer in the fundus. Exploratory gastrotomy seems a safer procedure. In a direct examination of the mucosa it is important to avoid abrading it with swabs or sucker end lest traumatic bleeding points be produced which would cause confusion. Osborne and Dunphy (1957) have given an account of 100 cases of upper gastro-intestinal haemorrhage treated

surgically; they found it necessary to open the stomach, and if indicated the duodenum also, in 40 cases and in so doing were able to establish the cause of the bleeding in all but 3 patients. When multiple gastric erosions are found a partial gastrectomy should be performed as this will remove the major part of the bleeding area and will cause a partial devascularization of the gastric stump Even when no source for the bleeding is found after a careful search, Tanner (1951) advises partial gastrectomy if the haemorrhage has been severe.

When partial gastrectomy is being performed it is essential to remove clot from the stomach to prevent possible inhalation afterwards. It is also advisable to inspect the fundus before completion of the anastomosis when resection is being done without a cause for the bleeding having been found.

In conclusion, it may be stated that surgery has a small but vital role to play in the treatment of gastro-duodenal haemorrhage by selecting for operation as early as possible those patients who are unlikely to do well under medical treatment, the factors influencing such a selection being chronicity of the ulcer, particularly if gastric, a patient over 40 years of age and recurrent bleeding after admission to hospital. The association of perforation and haemorrhage is an absolute indication for resection. Of those patients treated medically a number will require elective resection before leaving hospital to prevent further symptoms which may include another episode of bleeding

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OPERATIVE CHOLANGIOGRAPHY AND MANOMETRY OF THE BILIARY TRACT

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It has been recognized for some time that a relatively high proportion of patients treated by operation for disease of the biliary tract have residual and sometimes troublesome symptoms A number of critical reviews have assessed the proportion of unsatisfactory results after this type of surgery at between 15 and 30 per cent of the total (for example, Hellstrøm, 1938; Myers, 1953; Hess, 1955). More particularly it has been known for a long time that cholecystectomy for non-calculous cholecystitis is less likely to be successful in relieving pain than operation for cholelithiasis. Nevertheless, comparatively little attention has been devoted to this problem until quite recently.

It is evident that some of the poor results are due to associated and perhaps related pathology like chronic pancreatitis or chronic atrophic gastritis which are difficult to treat by either medical or surgical measures, but these cases do not account for all the surgical failures. Other patients relapse and may require further [illegible]

[illegible] finding of stones in the common duct after operation by experienced surgeons [illegible] the Mayo Clinic in 8 per cent of cases and others have quoted much higher figures; Hicken, McAllister and Call (1954), for example, found that stones had been left in the duct in 20 per cent of cases. Finally, however, there remains a group of patients in whom the persisting biliary symptoms are unexplained by any organic pathology, and in whom the trouble may lie in a dysfunction of the biliary tract or "biliary dyskinesia".

The object of this review is to consider 2 techniques of investigation which may help to reduce the number of unsatisfactory results after operations on the biliary tract

For several years most British surgeons have employed post-operative cholangiography by injecting opaque medium down the T tube in the common bile duct before removal of this drain. This undoubtedly reveals some, if not all, of the

calculi which have been overlooked at operation, but if residual stones are detected a second operation is still required. This technique is sometimes employed also to obtain reassurance for the surgeon that bile is able to flow into the duodenum; the demonstration of opaque medium in the duodenum in these circumstances is, however, either misleading, if pressures higher than physiological pressures have been used in running in the dye, or unnecessary since the presence of bile is easily detected in the stool. Clearly it would be much better to learn anything that the cholangiogram can reveal at the time of operation rather than 10 days later.

Per-operative cholangiography adds to the time and trouble which a surgeon must take in the course of an operation on the biliary tract; perhaps for this reason it has not yet become a general practice in Great Britain. It is, however, used routinely in some clinics, and we believe it is true to say that few who have given it a serious trial have failed to be convinced of its value. By its use the surgeon can avoid unnecessary exploration of the common bile duct, he can (with few exceptions) detect residual stones in the duct before the operation is completed and he can in some cases find pathological conditions difficult to diagnose by other means.

Cholangiography has the important limitation, however, that it does not usually reveal, or at least elucidate fully, any biliary dysfunction which may be present. The diagnosis of biliary dyskinesia may be suspected in a patient who has residual biliary symptoms in the confirmed absence of organic cause, but some method of investigation is required which will permit the full diagnosis of any disturbance of function, preferably either before or during the first operation on the biliary tract. One of the more promising techniques with this object is per-operative manometry and this is in practice conveniently combined with cholangiography.

OPERATIVE CHOLANGIOGRAPHY

The first reported radiological demonstration of the biliary tract was accidental. In 1918 Reich, in America, reported the case of a woman who had a discharging sinus between the tenth and eleventh ribs on the right side He injected the sinus with a bismuth paste and obtained a demonstration of the whole biliary tree. In 1921 Beall and Jagoda reported the demonstration of the bile ducts during a barium meal examination, and Tenny and Patterson (1922) reported a similar case in the following year Lanari and Squirru (1924) and Cotte (1925) published reports of demonstration of the duct systems by injecting Lipiodol into external biliary fistulae In 1932 Mirrizi of Cordoba described the first per-operative cholangiogram. In this country McNeill Love (1947, 1952) has described the technique and urged its routine use.

Technique

Cholangiography during the operation can be carried out with the equipment available in any hospital. A portable x-ray machine with the tube part covered by a clean or sterile cloth is placed above the patient when the pictures are to be taken and the cassettes with x-ray film are inserted into a cassette holder which is placed on the table under the patient. The cassettes may be inserted from the side by an assistant working under the sterile towels, or on a "shovel" which is pushed

down a long tunnel from the head end of the table. Better definition is obtained if a grid is employed over the cassette. An alternative arrangement is the use of a radiotranslucent table with the tube below the patient and the plate above. Tube and plate are mounted on the same bracket so that they move together. This technique is described in a paper by Mallet-Guy and Rose (1956).

Provided the cystic duct is not obstructed by stone or disease a good demonstration of the duct system can be obtained by injecting the opaque medium into the gall-bladder. To do this a straight cannula is tied into the fundus of the gall-bladder at the start of the operation. If, however, there is no doubt that the gall-bladder is to be removed the cholangiogram is obtained by inserting a curved cannula through an opening in the cystic duct into the common bile duct; a ligature is passed round the cystic duct to hold the cannula and prevent leakage. A narrow cystic duct may appear too small to accept the cannula, but can be dilated with suitable forceps. If the gall-bladder has been removed at a previous operation the stump of the cystic duct may be dissected out and cannulated, or a small opening made in the duct and the cannula held in position by a purse-string suture.

The radio-opaque fluid used should be non-irritating and should not be too dense to x-rays or it will obscure small stones. Lipiodol is not suitable because it is too opaque. Convenient fluids are the water soluble preparations used for pyelography or angiography, such as diodone or Hypaque made up in 25 per cent solution; stronger solutions are too opaque and may cause some irritation with consequent spasm. It is advisable to take 2 or 3 radiographs in each case. When the injection is made into the gall-bladder larger volumes are required; it is then convenient to inject 20 millilitres before the first exposure, a further 20 millilitres before the second exposure and then wait 2 minutes before taking a final film. The last picture gives information about the rate of emptying of the ducts. If injection is made into the common bile duct exposures may be made after injection of 10 millilitres, then after a further 10 millilitres and again after an interval of 2 minutes. A larger volume of opaque medium may be required if the duct is very dilated.

Normal cholangiogram

For purposes of description the bile ducts may be divided into the hepatic ducts and the common duct with its suprapancreatic, pancreatic and ampullary subdivisions. Normally the common duct is 3–5 millimetres in diameter though this may vary with the degree of photographic magnification. Hepatic reflux is usually seen after injection of 10–15 millilitres of fluid into the duct. The sphincter of Oddi is seen as a distinct narrowing of the lower end of the common duct. Dye should be present in the duodenum in the second radiograph and in the final picture more of the dye is in the bowel but the ducts are still outlined (Fig. 10).

Abnormal cholangiograms

Common duct stones are seen in the cholangiogram as filling defects which may be in the upper part of the duct (Fig. 11), or if the stone is impacted in the ampulla it may appear as a concave amputation of the duct with dilatation above (Fig. 12). It is rare for a stone to cause a complete obstruction and usually a small trickle of dye will be seen to pass the stone. Hepatic duct stones may be demonstrated by cholangiography when they are not revealed by instrumentation (Fig. 13)

FIG 10 (*a*)

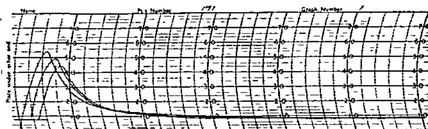


FIG 10—(*a*) Normal common bile duct pressure graph (*b*) Normal cholangiogram

FIG 10 (*b*)





FIG 11 (*a*)

FIG 11—(*a*) Cholangiogram showing dilated common bile duct sharply angulated at the junction between the supra-pancreatic and the pancreatic portions, at the angle so formed is a stone floating freely in the duct and another stone is proximal to the angle There is also a stone causing an almost complete obstruction at the lower end of the duct (*b*) Pressure graph taken in the common bile duct showing an abnormally high stabilized pressure at 22 centimetres of water

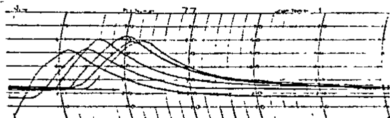


FIG 11 (*b*)



[illegible]
has passed beyond the stone into the duodenum (*b*) The pressure graph stabilized at an abnormally high pressure of 19 centimetres of water.

FIG. 12 (*a*)

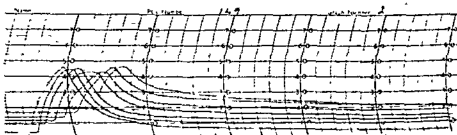


FIG. 12 (*b*)



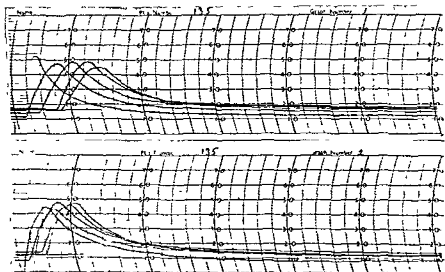
FIG. 13 —Filter bed of stones at the lower end of the common bile duct and several stones at the origin of the common hepatic duct.

When calculi have been removed from the ducts the cholangiogram should be repeated to make sure that none remain.

Obstruction at the lower end of the common bile duct may be due to a stone impacted in the ampulla, a tumour at the ampulla of Vater, fibrosis of the sphincter



FIG. 14.—Common bile duct of normal calibre



of Oddi, or a spasm of the sphincter. An ampullary neoplasm leads to a dilated duct and an irregular amputation of the termination of the duct. Fibrosis and spasm cause the duct to end like a finely sharpened pencil point (Fig. 14); the

differential diagnosis between fibrosis and spasm can be made only by manometric studies.

Carcinoma of the head of the pancreas produces an irregular amputation of the duct at a higher level with marked dilatation above (Fig 15), and a tumour of the hepatic duct is shown by obstruction of the normal reflux into the liver (Fig. 16)

Chronic pancreatitis may be present without radiological abnormality in the common bile duct but frequently more or less compression of the pancreatic

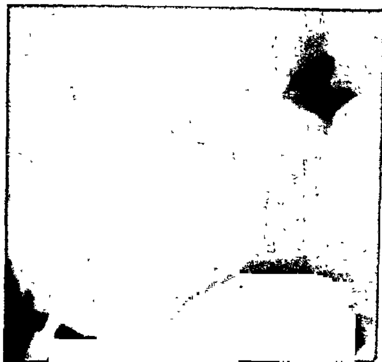
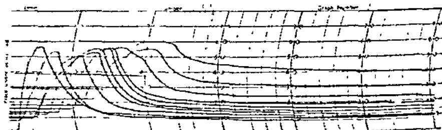


FIG. 15—Carcinoma of the head of the pancreas. The cholecysto-cholangiogram shows a large dilated gall-bladder and a dilated common duct which ends in a blunt irregular cone at the junction of the supra-pancreatic portion and the pancreatic portion The pressure graph taken in the gall-bladder shows a characteristic obstruction curve, each stabilized pressure being higher than the one preceding.



portion of the duct is seen. The pancreatic part of the duct may be narrow and elongated with angulation of the duct at the junction of the supra-pancreatic portion and the narrow zone (Fig 17). If obstruction of the duct by chronic pancreatitis is almost complete the radiological appearances may be difficult to distinguish from those of carcinoma in the head of the pancreas but certain features may help to differentiate the two; in chronic pancreatitis the dilatation of the ducts

above the obstruction tends to be less marked and the angulation of the duct at the upper border of the pancreas is more acute

In about 20 per cent of cases examined by per-operative cholangiography reflux of the opaque medium along the duct of Wirsung is observed (Fig. 18). About one-third of those cases occur in patients with chronic pancreatitis.

Alterations in the calibre of the ducts in the absence of other evidence of morphological abnormality are difficult to interpret. Abnormal dilatation may be due to



Fig 16

Fig 16 —The cholecysto-cholangiogram shows that the common hepatic duct is obstructed near its origin The patient had a primary carcinoma of the hepatic duct



Fig 17

Fig 17 —Chronic pancreatitis A common bile duct which is dilated in the supra-pancreatic part, but narrows considerably as it proceeds distally in the pancreatic part. The termination is irregular

obstruction or to previous obstruction of the lower end of the duct but it is found in some patients who have no organic lesion The latter finding may be evidence

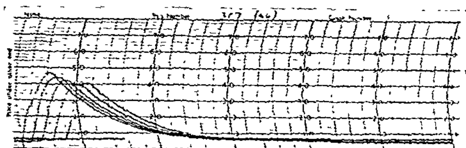


Fig. 18 (*a*)



Fig 18 (*b*)

[illegible] of hypotonia



Fig. 19 (*a*)

Fig 19 *a* and *b* —Massive dilatation of the hepatic, the common hepatic and common bile ducts No organic cause [illegible] cholecystectomy; symptoms have been completely relieved by right splanchnicectomy

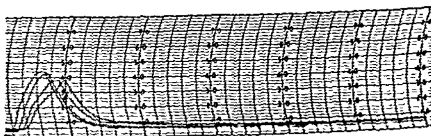
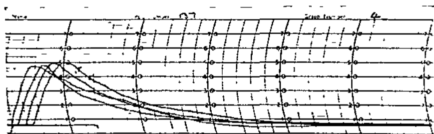


Fig. 19 (*b*)

measurements show evidence of hypotonia. A relatively narrow duct system may be associated with manometric readings indicating a hypertonic state, but is also found with low pressures (Fig 20) In the diagnosis of dyskinesia it appears that the manometric studies are an essential addition to cholangiography.



FIG 20—An abnormally narrow common duct in association with a low stabilized pressure within the common bile duct



MANOMETRY OF THE BILIARY TRACT

Cholangiography helps in the diagnosis of morphological abnormalities of the biliary tract but, at least with the techniques at present employed, it gives little information about the motor functions which may be equally or, in some cases, more important.

Historical

Heidenhain, in 1868, first attempted to measure the pressure of the bile and in 1888 Oddi attributed the pressure within the common bile duct to the sphincter which now bears his name In 1893 Doyon demonstrated the contractility of the bile duct Bergeret, Caroli and Debouvrey (1940) combined a radiological examination of the biliary tract with manometric measurement of the pressure within the

tract; their method was to *intubate* the *biliary* tract at a preliminary operation, to carry out radiographic and manometric studies some time later and thereafter *to undertake any definitive surgical treatment which* was judged necessary *It* is possible to carry out the major part of Caroli's method during a single operation, but the procedure is very time consuming. This *method, and more particularly its* later modification of manometry by transparieto-hepatic vesicular puncture (Kapandji, 1950), give a very adequate concept of biliary tract function but both are difficult and laborious procedures requiring considerable skill in practice and experience in interpreting the results.

Mallet-Guy (1947) described a simpler method of recording biliary tract pressures during the operation at which definitive surgery is to be carried out. This technique, *which is described in the following paragraphs,* requires a relatively short time and is thought to give adequate information on which to base surgical treatment in all but *the more complicated cases.*

Technique

When manometric studies are to be made on the biliary tract the type of anaesthesia used is of great importance; nitrous oxide, oxygen and ether are used without any premedication (Feit, 1951) The pressure within the biliary tract is under the control of the sympathetic and parasympathetic systems and any drug which affects these systems will falsify the manometric readings. Any great alteration in blood pressure will also affect the biliary pressure recordings and manometric studies are therefore unreliable in patients with marked hypotension or when vasoconstrictor drugs have been required to maintain a satisfactory level of blood pressure. It appears that anaesthesia with nitrous oxide, oxygen and ether does not alter the biliary tract tone or motor function significantly and this anaesthetic technique *should be adhered to rigidly in any case until pressure records have been completed*

The pressure in the biliary tract is recorded on a manometer which resembles the usual recording barograph, except that the drum revolves once every 30 seconds The aneroid manometer is connected to the biliary tract by a tube which rises 2–3 feet above the patient as it passes from the biliary tract to the manometer. It is important to see that the tube rises continuously and at no point falls from the patient until it has reached its maximum height, after which it falls to the manometer, which is on a *level with the patient. The raised loop contains* air and the fluid in the part of the system connected to the biliary tract is prevented from reaching the manometer by the elevation of the tube and by a water trap within the manometer box. Interposed in this tube about 1 foot from the cannula in the biliary tract is a T junction which allows a syringe with inlet and outlet valves to be connected in the pressure system (Fig. 21).

The pressure is recorded by injecting about 5 millilitres of isotonic saline at body temperature *into the system; this causes the recording pen to rise* and then fall slowly as pressure stabilizes at a lower level. This manoeuvre is repeated several times until successive pressures stabilize at approximately the same level. The final stabilized pressure is the pressure which the sphincter of Lütkens (if taken within the gall-bladder) or the sphincter of Oddi (if taken within the common duct) will support

The normal stabilized pressure within the gall-bladder is about 18 centimetres of water and the normal limits in the common bile duct are from 8 to 14 centimetres of water.

The normal pressure curve descends rapidly and regularly during the first 5 seconds and then much more slowly, being concave in shape (*see* Fig. 10). Sometimes small respiratory undulations are transmitted to the curve, or the curve may descend in well-marked steps.

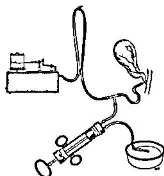


FIG 21.—Diagram showing the apparatus for manometry of the biliary tract.

Abnormal pressures and their significance

Hypertonia

A raised pressure indicates a state of hypertonia in the biliary tract, this may be functional, either primary or secondary, or it may be organic due to some mechanical obstructive lesion Sometimes a combination of functional and organic causes is responsible.

The manometric findings in hypertonia are distinctive, the pressure curve, instead of falling rapidly to about 15 centimetres and then more slowly to between 8 and 14 centimetres (when taken in the common duct), descends more slowly to stabilize at a higher level than normal In complete or almost complete obstruction each stabilized pressure is higher than its predecessor (*see* Figs. 12 and 15)

When a high stabilized pressure is found the operator must establish whether this is produced by a functional or an organic lesion, or a combination of the two. If there is no evident organic cause of obstruction the lower vagal fibres on the lesser curvature of the stomach are blocked by infiltration of this region with a local analgesic If the cause is purely functional a subsequent series of manometric recordings will show a pressure curve which stabilizes at a normal or subnormal level (*see* Fig 14). If the cause is organic there will be no significant change after vagal block, and if both functional and organic factors operate the pressure may fall but remain above normal When an organic lesion is present the cholangiogram which is made after completion of manometry will help in the diagnosis by showing whether an obstructing stone is present or by demonstrating the findings which suggest another form of obstructive lesion such as fibrosis of the sphincter of Oddi It has been noted that cholangiography alone will not differentiate between fibrotic stenosis and spasm at the sphincter of Oddi; these conditions can be distinguished only by observing the effect of vagal block on the pressure tracing.

In hypotonic states of the biliary tract the pressure curve falls rapidly to stabilize at a low level (*see* Fig. 18); the final level may sometimes be at a negative pressure. As already noted the cholangiogram in hypotonia usually shows abnormal dilatation of the gall-bladder and duct system (*see* Fig. 19) and the ducts may empty rapidly. Rarely the hypotonic ducts are unusually narrow (*see* Fig. 20)

Results

The work of some Continental surgeons appears to show that dyskinesia of the biliary tract is much commoner and more important than has been believed. Mallet-Guy (1950) reported that out of a series of 1,100 cases he found a hypotonia in 228, and hypertonia in 206 Caroli (1950), however, believed that hypotonia may be an artefact due to anaesthesia and places importance only on a hypotonia diagnosed post-operatively. Kapandji (1952) using the transparieto-hepatic vesicular puncture and no anaesthetic (except a small cutaneous local analgesic) reported findings similar to those of Mallet-Guy.

One of the authors of this review (J D R.) has studied 300 consecutive cases of biliary tract disorder, 289 of which were non-malignant, by per-operative manometry and cholangiography In the non-malignant cases he found evidence of vesicular hypotonia in 70 patients, hypotonia of the common bile duct in 91 patients, vesicular hypertonia in 33 patients, and a common duct hypertonia in 30 patients. The full significance of these observations requires further study and assessment but the admittedly high incidence of unsatisfactory results after conventional biliary tract surgery suggests that these findings cannot be ignored. Study of a series of 37 patients with post-cholecystectomy syndrome showed that 11 had purely functional disorders, 10 had some form of dyskinesia associated with morphological abnormalities, and 16 had purely organic lesions. Only half of those with organic lesions had residual calculi, the remainder of this group being accounted for by chronic pancreatitis, cholangiohepatitis, congenital abnormalities, appendicitis, and duodenal ulcer.

OPERATIVE TREATMENT OF BILIARY DYSKINESIA

The operative treatment of patients shown by manometric studies to have biliary tract dysfunction is an even more controversial subject than that of diagnosis. Mallet-Guy and his colleagues (1953) have shown by experimental studies on animals that vagal section reduces the pressure in the bile ducts and that right splanchnicectomy increases the pressure. He and others (for example, Poilleux, 1953) have for many years treated cases of hypertonia of the biliary system by division of the vagal fibres on the lesser curve of the stomach and cases of hypotonia by right splanchnicectomy, and have claimed excellent results from these measures Our experience appears to confirm the value of these operations in properly selected cases, though, as might be expected on theoretical grounds, the results of division of the right splanchnic nerves alone are less certain than those of vagotomy

Hess (1955) believed that a right splanchnicectomy should be reserved for those cases of essential hypotonia which had pain so severe that a laparotomy had been undertaken. He would not contemplate a right splanchnicectomy when a hypotonia

was associated with gall-stones and would be satisfied with a simple cholecystectomy, leaving the splanchnicectomy for those cases which returned with painful symptoms.

Transduodenal sphincterotomy (with suture of mucosa of bile duct to mucosa of duodenum along the sides of the incision to preserve the opening) is undoubtedly indicated in true fibrotic stenosis of the sphincter of Oddi and may also be employed in the relief of spasm of that sphincter.

In conclusion it must be admitted that the whole subject of dyskinesia of the biliary tract, its investigation by manometry and its treatment by neurectomies has been viewed with much suspicion by British surgeons but the significance and value of these procedures have not yet been properly tested in this country.

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71.

CROHN'S DISEASE

By HAROLD C. EDWARDS, C.B.E., M.S., F.R.C.S.

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Changes in the gastro-intestinal tract and associated lymph nodes which are characteristics of established Crohn's disease may occur anywhere in the alimentary canal from the oesophagus to the rectum. These changes do not necessarily imply a common aetiology. Both the bowel wall and its lymphatic system are limited in their "reaction potential" to harmful agencies, and they may react in like manner to agencies of widely differing natures.

It is known, for example (Edwards, 1957), that such changes in the caecum and adjacent ascending colon may be due to a solitary ulcer, to chronic diverticulitis, or to appendicitis, and that there is in this situation a pronounced link with tuberculosis. When these changes affect the terminal ileum, however, they give rise to a distinct and familiar clinical syndrome of great importance to the clinician. It would be appropriate to confine the eponymous title of Crohn's disease to this syndrome, for it is in connexion with it that Crohn's interest was first aroused.

PATHOLOGY

The naked-eye appearance of the bowel in Crohn's disease is too well known to bear further description, but it is as well when discussing the aetiology to keep in mind the chief features of the microscopic anatomy.

The main impact seems to fall upon the *submucous* coat, and ulceration of the mucosa would appear to be secondary (Hadfield, 1939). In this respect, therefore, Crohn's disease differs from ulcerative colitis, which is primarily a disease of the mucosa. The most pronounced change in the active or acute phase of the disease is a great increase in the submucosal lymphadenoid tissue, to which the typical cobblestone appearance of the surface of the mucous membrane is due. The lymphatic vessels themselves become blocked with cells and lymphoedema results. The associated lymph nodes become correspondingly enlarged, and giant cell systems form both in them and in the bowel wall. When ulceration of the mucosa occurs, infection will cause a superadded inflammatory reaction in both the submucosa and the lymph nodes concerned, and this eventually leads to a fibrosis which may obliterate the more specific features of the lymphadenoid hyperplasia.

Two further changes which are thought to have a bearing on the aetiology have recently been described, namely, an increase in the number of Brunner's glands

(Kawel and Tesluk, 1955) and an increase in the number of ganglion cells in the myenteric plexus (Davis, Dockerty and Mayo, 1955).

Brunner's glands

Landboe-Christensen (1944) made a detailed study of the distribution and quantity of duodenal glands in man, and concluded that no such glands were normally to be found beyond the upper part of the jejunum. Kawel and Tesluk studied 34 specimens of Crohn's disease, and in 16 of these found Brunner-like glands in the wall of the affected bowel. The significance of this finding is obscure, but it was thought that the glandular anomaly followed rather than preceded the disease Kawel and Tesluk believed that the anomaly has a bearing on prognosis, for recurrences (8 out of 13 patients followed-up) were restricted to those in whom it had been demonstrated. None of the 18 cases in which no glands were found had recurred at the time of the investigation.

Myenteric plexus

Davis, Dockerty and Mayo compared the numbers of ganglion cells in the myenteric plexus in 24 specimens of Crohn's disease with the numbers found in 24 specimens of normal small intestine, and found that they outnumbered the latter by 3 to 1. They noted that the increase was not confined to the obviously diseased areas of the ileum, but that adjacent, and apparently normal, segments were also affected The number of cells were directly proportional to the age of the disease, but unrelated to its extent. No significance can be attached to this finding at present.

EXPERIMENTAL WORK

Lymphatic obstruction

The clear demarcation of the disease suggests that the lymphatic oedema is secondary to swelling of the lymph nodes, and the occasional presence of well-defined skip areas is relevant The experimental work of Reichert and Mathes (1936) lends support to this theory They injected such substances as bismuth oxychloride, rosaniline dye, and sodium morrhuate, either alone or in combination, into the mesenteric and submucosal lymphatics of 13 dogs An intravenous injection of *Bacterium coli* was given to 4 of the animals from 1 to 3 hours beforehand All but one of the dogs had developed changes in the bowel similar to those of Crohn's disease at the time of death, 1 month or more after the injection. The changes were most marked in those dogs who had been injected with the *B. coli* emulsion.

Ingestion of foreign particles

An experiment which in some respects is complementary to the foregoing was carried out by Chess and his colleagues (1950) who produced changes seemingly identical with those of Crohn's disease by feeding dogs on talcum powder or finely divided sand, or both, in quantities over a sufficient period of time. Some of the dogs were given an intravenous injection of *B coli*, or a mixture containing this organism and *Staphylococcus aureus*.

It was found that the terminal ileum ingested the particles with the subsequent development of chronic enteritis, with hyperplasia of the mesenteric lymph nodes and, in a number of instances, microscopic granulomatous lesions of the liver as well. Talcum powder seemed to be more detrimental than sand, and the smaller the particle the more potent it seemed to be. The injection of organisms, which produces no effect in healthy control animals, added to the degree of damage to the bowel, from which it was concluded that infection is not a primary but a possible accessory factor in Crohn's disease.

The two experiments are mutually supportive in that they both demonstrate that lymphoedema of the submucosa identical with that of Crohn's disease is dependent upon lymphatic obstruction, and it will be noted that the initial changes of Crohn's disease are due to this cause. Jones and Paulley (1949) suggested some fault in intestinal fat metabolism, and the hypothesis has been put forward that fatty acids themselves may cause a blockage in the lacteals. In view of the findings of Chess and his colleagues it has been suggested that the silica or talcum powder, or other similar substances contained in certain tooth pastes and powders, may have a bearing on this problem.

CAUSATION

No single specific cause has yet been found—possibly because none exists. The evidence indeed suggests that the condition is, like duodenal ulceration, the result of a combination of factors

Tuberculosis

The theory that Crohn's disease is of a tuberculous nature seems to be disproved by two factors: (1) caseation does not occur either in the thickened intestinal wall or in the swollen lymph nodes, and (2) the presence of the tuberculosis bacillus cannot be demonstrated.

Frank tuberculous enteritis, in which the ileum looks exactly like the ileum in Crohn's disease, may, however, occur (Fig. 22) Furthermore, there is a very close clinical association between phthisis and granulomas of the caecum, in which the morbid anatomy is identical with that of Crohn's disease (Edwards, 1957) It would be unwise, therefore, to deny the possibility that the disease may in some cases be an unusual manifestation of tuberculosis.

The question may be answered by the observations of Nethercott and Strawbridge (1956) who claimed that it is possible to identify a tuberculous lesion by demonstrating the presence in it of tuberculous bacterial residues, namely, mycolic acid and diaminopymelic acid.

Sarcoid

It is nearly 20 years since Hadfield first suggested that Crohn's disease may be a form of sarcoid During this period, however, there have been no recorded examples of generalized sarcoidosis developing in patients with Crohn's disease, and negative results have been reported from the Kveim test (Crohn and Janowitz, 1954).

Acute ileitis

It is very doubtful if acute ileitis is a related disorder, though it is fully recognized that the stage of onset of Crohn's disease may be extremely short, rapidly developing into an acute abdominal condition for which exploratory operation is often performed on a diagnosis of acute appendicitis with abscess formation. There is little evidence that acute mesenteric adenitis associated with a "pink" terminal ileum—sometimes found in infants and young children at operation for suspected appendicitis—is an antecedent cause.

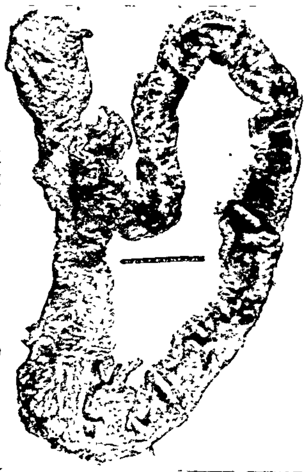


FIG 22.—Primary tuberculosis of the small intestine in a man aged 34 years (autopsy specimen) Emaciated, with high pyrexia, ascites, oedema of legs and finger clubbing. Laparotomy (18.7 47), 5 feet of ileum involved Short-circuit. No improvement Patient died 8.9 47 from massive pulmonary embolus Histology showed granulation tissue in the wall of the bowel with caseation, and subserosal miliary tubercles. Mesenteric lymph nodes enlarged, but not caseating Tuberculous nature confirmed by guinea-pig inoculation (*Reproduced from Modern Trends in Gastroenterology, second series London, Butterworth*)

Social status, race, and familial predisposition

Crohn's disease is unrelated to social status, and no significant racial predisposition has been established, though there has been a suggestion that Jews are more liable than are Gentiles. There is, however, very definite evidence of a genetic or an environmental factor (Crohn, 1958; Heard and John, 1956). The

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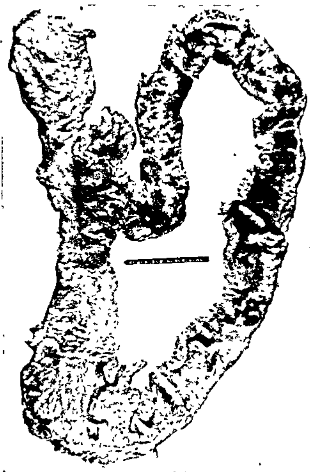
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perhaps a raised erythrocyte sedimentation rate with a slight rise in evening temperature, investigation, including radiological examination, is negative. There is some danger at this stage that nervous dyspepsia will be diagnosed, and that the patient subsequently be treated solely by psychiatric means; or that the patient be submitted to operation with a diagnosis of grumbling appendix. Such an undertaking is not necessarily harmful provided the surgeon is alive to the danger of appendicectomy, for it will provide a positive diagnosis, particularly if a lymph node is removed for microscopic examination. Suspicious radiological findings may sometimes precede the appearance of physical signs In themselves they pass unnoticed, but taken in conjunction with a history as described are to be regarded as significant.

Such a march of events is of course by no means the rule In some patients, particularly amongst the later age groups, the disease process may be insidious, with the development over a number of months of symptoms and signs of chronic obstruction (Fig. 23*a* and *b*), or, particularly in young subjects, it may be a very acute process from the start, a severe illness developing with great rapidity. The first sign in 3 of the author's patients was acute ileus At any stage of the disease, including the phase of onset, an acute perianal abscess may develop, leading to fistula, as was noted in the case histories of 6 patients, of ages ranging between 21 and 26 years, before the diagnosis of Crohn's disease was established The presence of perianal infection in association with a history of diarrhoea in young people should therefore be regarded as an important pointer to diagnosis The abscess is probably due to infection in the crypts of Morgagni and is associated with the frequency of stool According to Crohn the significance of perianal abscesses and fistulas has not been sufficiently appreciated. He is of the opinion that "suppurative perianal fistulas in the presence of diarrhoea indicate a pathologic inflammatory process somewhere in the intestinal tract . . . They do not occur in nervous, gastrogenous, pancreatic, allergic, or thyrogenic diarrhoeas". There will be general agreement with this view. When the diagnosis is in doubt, inspection of the bowel through a small grid-iron incision is a valuable and satisfactory procedure. A lymph node may be taken for microscopy

Phase of physical signs

The clinical characteristics and radiological features of established Crohn's disease are well known; the significance of only certain of the leading signs and symptoms is therefore discussed.

Diarrhoea

This is the most constant symptom of the disease in all its stages, though it may at first be slight and intermittent, and is never as severe as in ulcerative colitis. Though severe bleeding may very occasionally occur, blood is usually not to be observed in macroscopic quantities in the motions In the typical case, fat digestion is not impaired If steatorrhoea is present it betokens extensive involvement of the intestine Cooke (1955) found that the presence of steatorrhoea before operation is associated with high post-operative recurrence and mortality rates, and surgical treatment in such cases is therefore strongly contra-indicated.



Fig 23*a*.—Straight skiagram of the abdomen to show fluid levels diagnostic of acute obstruction Treated by intubation.



Fig. 23*b* —Characteristic appearance of Crohn's disease at operation 3 weeks later Hemicolectomy performed.

Pain

A characteristic feature of the pain in all phases of the disease is that it may precede the call to stool, and may be relieved by defaecation. Pain is usually situated in the region of the right iliac fossa or across the lower abdomen, and becomes severe and colicky in nature only when the disease is sufficiently advanced to cause narrowing of the lumen of the ileum. Low back pain may also be present. It is important to realize that during the acute stages of the disease diffuse colicky pain does not necessarily demand surgical treatment as an urgent measure, the narrowing of the lumen of the ileum which causes pain at this stage will probably be due to lymphatic oedema and spasm of muscle and not to fibrosis. Complete rest at this time is likely to be accompanied by some degree of resolution, so that the attacks become less insistent and the immediate danger is averted Colicky attacks over a lengthy period associated with visible peristalsis denote fibrosis, and relief by operation will usually be indicated. It should be noted that both nausea and vomiting are rare.

Anaemia

A varying degree of anaemia is often, though not necessarily, present, and the haemoglobin concentration may be down to a level of 70 per cent (Haldane) without there being any macroscopic evidence of blood loss. In one of the author's patients the anaemia was megaloblastic in type and achlorhydria was present This patient had had a non-exclusion short-circuit operation performed 5 years previously without affording relief. Medical treatment failed to benefit the anaemia until excision of the diseased mass was performed This was followed by a partial recovery to the extent that the red cell count was maintained at about 4 million cells per cubic millimetre, and the menses, previously in abeyance, became normal.

The swelling

The swelling is not always to be observed in the right iliac fossa, but may be placed more centrally. In one of the author's patients it was situated low in the left iliac fossa Occasionally it may lie wholly within the pelvis, and its presence be revealed only by rectal or vaginal examination Repeated estimation of the size and character of the swelling is a very important guide to the progress of the disease.

Fever

During this phase the evening temperature may rise to 101–102° F, and continue so for weeks. Occasionally it may reach an even higher level It may suddenly subside without obvious reason.

Phase of complications

The most important complications are those of obstruction and fistula. Perforation is rare, and is more liable to cause a walled-off abscess than peritonitis. Severe intestinal haemorrhage has been recorded (Crohn mentions this complication in 25 of 542 cases). Peptic ulcer (usually duodenal), polyarthritis, and erythema nodosum may be associated disorders. Pregnancy may have an adverse effect upon the course of the disease, but need not be feared when the disease is absolutely

quiescent, or after successful surgery. When the disease commences during pregnancy it is likely to run a severe course, and in this respect is similar to ulcerative colitis.

Obstruction

Symptoms of intermittent obstruction are a very common late feature of the disease, and are then an indication for surgery. Obstructive attacks during the active phase of the disease, however, should not be regarded as a signal for surgical intervention, and the same is true of the more acute ileus that may occur early in the course of the disease. In such cases, reliance must be placed on adequate intubation (*see* Fig. 23).

Cooke (1955) drew attention to the importance of the potassium balance in relation to the problem of obstruction. In Cooke's view the symptoms may be due to potassium depletion resulting from chronic diarrhoea. The deficiency deprives the normal intestine above the lesion of its contractile powers. In severe cases the exchangeable potassium may fall to very low levels. On this evidence it would seem of importance, therefore, to determine the potassium level in all cases and to make good any deficiency.

Fistula

The mechanism of fistula formation is not clear. It is not due to abscess formation, as in diverticulitis, but probably to lysis of the sodden ileal wall with spreading of this process to an adherent operation scar, or neighbouring hollow organ.

External abdominal fistulas may be single or multiple. It is rare for a fistula to form except through a laparotomy scar. Crohn did not encounter a single case in 542 patients. The author has, however, had experience of one patient who developed a fistula in the right iliac fossa during conservative treatment for what was wrongly considered to be an appendix abscess. As has been noted, appendicectomy performed during the active phase of Crohn's disease increases the risk of fistula formation, and is to be avoided. The development of a fistula following appendicectomy may be the first pointer to diagnosis.

External fistulas rarely heal spontaneously, and are therefore to be regarded as an indication for surgery. Internal fistulas are most commonly ileo-ileal or ileo-caecal, but occasionally the sigmoid colon is involved, and very rarely the rectum. No hollow viscus is exempt, and examples of fistula into the uterus, a fallopian tube, a ureter, and even the duodenum, have been described. Some are compound, for example, ileo-vagino-rectal. One of the more important, though rare, internal fistulas is the ileo-vesical. The fistula is not as a rule a frank opening through which obvious intestinal contents pass into the bladder, but more of the nature of a narrow track, and hence it may be the unsuspected cause of chronic and intractable cystitis.

Perianal and perirectal fistulas

Attention has already been called to the significance of perianal abscess, sometimes leading to fistula, as an early diagnostic sign. The over-all incidence is high—varying from 18 per cent (Penner and Crohn, 1938) to 31.6 per cent (Jackman and Smith, 1943). A much rarer and more serious form of perirectal fistula is that

which burrows through the pelvic fascia, commencing apparently in the pouch of Douglas, and passing into the rectum above the sphincter, or into the vagina, or the ischio-rectal fossa. It is suggested that such a fistula may be due to the collection on the pelvic floor of proteolytic material from the diseased ileum

RADIOLOGICAL EXAMINATION

Though symptoms usually precede any observable alteration in outline or motility of the terminal ileum, the latter may themselves precede the development of physical signs. In other words, the development of radiological changes is sandwiched somewhere between the phase of onset and the phase of physical signs.

The early radiological abnormalities are those of spasm, or suggest swelling of the mucosa. Such changes are not diagnostic of Crohn's disease, but are significant if associated with an appropriate clinical history.

The earliest definitive radiological change is the disappearance of the mucosal pattern of an area of terminal ileum, so that it resembles a tubular cast The ileum proximal to it may be a little distended, there may be some evidence of spasm in the wall of the bowel on the other side of the ileo-caecal valve, and the normal angle of incidence between ileum and colon may be altered.

The string sign of Kantor is rarely, if ever, demonstrable before the stage of physical signs has been reached, and the diagnosis is obvious on clinical grounds. At the same time it is a mistake to think that the presence of the string sign means that the bowel is already converted into a fibrous tube, and that the activity of the disease has waned or wholly burnt out Such is very far from being the case, for the radiological narrowing of the lumen is more than likely to be due to a combination of spasm and oedema, and it may thus be at least partially reversible. Indeed, it is quite impossible to correlate this characteristic radiological appearance with any degree of permanent or irreversible change, and its discovery is not necessarily to be regarded as an indication for surgical intervention.

The value of radiology in confirming the presence, situation, and degree of obstruction, and in the investigation of fistulas, is well recognized

MANAGEMENT

Crohn's disease is no longer to be regarded as a surgical lesion to be extirpated without delay, but primarily as a medical problem with clear indications for surgical intervention, and operation should be avoided during the active or florid stage of the disease unless medical management has failed and the condition of the patient deteriorates

If the disease is met with unexpectedly at operation, for example, for suspected appendicitis or a gynaecological disorder—as is very frequently the case—the intestine should not be interfered with A mesenteric lymph node should be taken for section, and the abdomen closed with great care. There can be no objection to a diagnostic exploration where doubt exists This is best done through a small grid-iron incision in the right iliac fossa, with as little disturbance as possible.

Medical treatment

Rest is the first essential, with freedom from emotional stress. Though it may take many months and demand great patience, it should be enjoined until all signs of activity of the disease have disappeared. The disease cannot be said to have burnt out until the temperature, haemoglobin estimation and the erythrocyte sedimentation rate are within normal limits, the weight is steady or increasing, and the patient feels well again. The diet should be non-residue and rich in calorie value Antibiotics are probably worthless and are used, if at all, with caution, for they may cause generalized enteritis (Zetzel, 1956).

Opinion as to the place in treatment of ACTH and cortisone is varied Some clinicians are obsessed by the hazards they create, of bleeding and perforation, and abjure them, whilst others, including Crohn, use them as a routine of treatment, commencing with ACTH by injection over a course of weeks, and replacing this with cortisone by mouth over a considerable period. One of the undoubted benefits of this treatment is the improvement in appetite and sense of wellbeing.

The use of steroid compounds appears to be definitely indicated, though perhaps as a counsel of despair, for fulminating cases who deteriorate in spite of routine medical care, as a preliminary to surgical intervention.

Radiotherapy

Treatment by x-rays has been given a trial notably by Kiefer, Marshall and Brolsma (1950) and Bargen (1954, 1957) The latter regards it as the most important of all therapeutic agents. The treatment is administered in courses, usually 3 in number, given at intervals of 1 month The abdomen is divided into 4 fields, each about 15 centimetres × 15 centimetres, and each field is exposed to 150r on successive days, so that a single course lasts for 4 days.

Bargen claims that of 150 patients so treated a large number have benefited. In a few radiological normality of the terminal ileum has been re-established.

Prognosis of medical treatment

Crohn (1958) treated 83 patients medically for periods up to 25 years, and his results are recorded in the Table.

TABLE

Years	*Well*	*Improved*	*Unimproved*	*Total*
1	8	6	7	21
2	8	2	4	14
3	12	1	3	16
4	7	2	0	9
5	3	3	0	6
6–10	9	1	2	12
11–15	2	0	1	3
16–25	2	0	0	2
	51	15	17	83

During this 25-year period 16 patients died, 8 of them from the disease. These cases are presumably not included amongst the unimproved. It is perhaps significant that such a small proportion of Crohn's cases—85 out of between 500 and 600—were not operated upon. It will be noted, however, that the numbers not operated upon have increased during the past few years (though their proportion to the whole is not stated) and this illustrates the modern trend towards conservatism.

Surgical treatment

The indications for surgery are as follows:

Uncomplicated cases

(1) Patients during the acute phase in whom the disease progresses despite medical care Pre-operative steroid therapy may be employed with benefit.
(2) Chronic localized disease which, though not extending, is persistent and intractable. This applies particularly to older patients, and the results of radical surgery are probably better than for any other group in this category.
(3) Patients who, despite medical care, suffer recurrent attacks of abdominal pain.

Complicated cases

(1) All external fistulas, in principle. Severe recurrent cases with multiple fistulas may, however, be beyond the power of surgery to improve them.
(2) Chronic obstruction
(3) Internal fistulas between the intestine and other viscera, such as the bladder.
(4) Recurrent perianal inflammation.
(5) Haemorrhage and perforation.

Note, however, that when the disease is widespread and associated with steatorrhoea, surgery is contra-indicated

Limitations of surgery

The experience of the past 25 years, during the early part of which Crohn's disease was regarded as primarily a surgical problem, has shown catastrophic results of injudicious surgery. Too much was attempted too early. If, in assessing surgical results, the term recurrence is used in its widest sense so as to include both failure to relieve major symptoms and the reappearance of symptoms after a temporary respite as well as cases of recurrence proven by re-operation or radiology, then the failure rate of surgery of this nature is well over 50 per cent for a 5-year period (Bockus, 1954), rising to 80 per cent after 15 years (Mayo Clinic). The lesson learnt is to avoid operation during the acute phase.

Scope of the operation

The essential step in the operation is the cutting across of healthy ileum above the diseased area, and implanting it into the transverse colon (exclusion ileo-transverse colostomy). A simple side-to-side ileo-transverse colostomy is of very

doubtful value and should therefore not be contemplated. Whether or not the intervening segment of bowel which includes the diseased portion is removed at the same time (primary radical resection—right hemicolectomy) should depend on the circumstances of each individual case. A great deal of play has been made with statistics to prove the superiority of the exclusion operation over resection, and *vice versa*. All agree that the exclusion operation is less dangerous; a self-evident truth not requiring proof by statistics. There is, however, still some difference of opinion as to the relative reliability of the two operations as regards cure. Garlock and his colleagues (1951) recorded a recurrence rate of 46 per cent after resection and 22·8 per cent after exclusion Crohn (1958) found little difference between the two—both are about 30 per cent—whereas Marshall and Fecher (1954) believed that resection is the only method offering improvement or permanent relief. It will be remembered that these statistics date back mostly to the earlier surgical period. There is reason to believe that in recent years the outlook has become far more hopeful as the result of a more judicious use of surgery.

Choice of operation

In the author's opinion the *relative* indications for the two operations are as follows·

(1) Exclusion ileo-transverse colostomy (*a*) during the active phase; (*b*) where complications such as fistula are present which may make resection a hazardous procedure. In some such cases ileo-transverse colostomy may well be the first stage in surgical treatment, and be followed by resection; and (*c*) where chronic obstruction exists.
(2) Resection (*a*) in older people in whom the disease is quiescent and fibrotic, and the bowel mass is not adherent to surrounding structures; and (*b*) as a second-stage procedure, following ileo-colostomy.

Technique

There is one *sine qua non* for success—the transection must be through healthy bowel. Failure to perform this may well have contributed to a high recurrence rate. It is not easy by naked-eye inspection alone to be sure on this point, particularly if operation has to be undertaken while the disease is still active or if changes due to chronic obstruction are present.

It will be found helpful to confirm normality by frozen section, though the method is not infallible. The two incriminating microscopic features are lymph-oedema and fibrosis in the submucous layer. The mucosa itself may be quite normal.

Pre-operative preparation

Rest in bed for a period for those patients in whom diarrhoea is still troublesome is a very helpful precaution. Blood transfusion may be required, and the serum potassium level is estimated, particularly when there have been symptoms suggestive of chronic or intermittent obstruction, or when diarrhoea has been persistent

The value of steroid therapy before operation in fulminating cases has already been mentioned Phthalylsulphathiazole 10 grammes is given daily for the 4-5 days

preceding operation, and 1 gramme of streptomycin on the morning of operation, followed by 0 5 gramme twice daily until the bowels act, usually on the fourth or fifth day after operation. The action should be allowed to "happen", and no artificial stimulus of any kind, either by mouth or by rectum, should be permitted.

Operation

Exclusion operation.—The incision should be mid-line subumbilical. If there is a previous operation scar or fistula it will be necessary to make an incision to the *left* of it—never to the right. The diseased bowel is interfered with as little as possible. It may not even be seen if adhesions around it are dense. The ileum at a point about 12 inches above the disease is identified and inspected, and the mesenteric lymph nodes in its immediate proximity are inspected for any swelling If the bowel looks normal a linear portion is removed from near the antimesenteric border and frozen sections are made While waiting for the result the transverse colon is identified and drawn into the wound. If the omentum is adherent to the affected bowel it must not be separated, but divided between ligatures if necessary. Usually, however, it will be possible to display the under surface of the transverse colon to which the anastomosis is to be made without disturbing the omentum. The site of election in the transverse colon should be as near the hepatic flexure as convenience permits Usually it is somewhere between this and the main branch of the middle colic artery—rather nearer to the latter.

The anastomosis should be made to the transverse colon *under* the great omentum, the taenia libera being the base line which receives the first layer of stitches. It will usually be found that the mouth of the transected ileum will be larger than in the normal person because there is an element of obstruction in most cases, so that the size of the anastomosis will be quite adequate. If it is felt that the ileal lumen is rather too small it can be enlarged by cutting down the antimesenteric border No crushing clamps should be used for transection—or at least not on the proximal side. All that is needed is a non-crushing intestinal clamp placed at some distance and closed sufficiently to stop intestinal contents escaping

It will of course be necessary to divide the mesentery to enable the ileum to lie comfortably against the colon—perhaps for 2–3 inches The small mesenteric blood vessels should be picked up individually and tied with fine thread.

The ileum distal to the site of transection is ligated with stout thread or silk before division and the stump inverted and buried with 2 or 3 purse-string sutures. The suture material for the anastomosis is not a major issue, for modern catgut is reliable. The important matter is the use of 2 layers, with closely placed stitches After the anastomosis is finished and tested the omentum is placed above and to the side of it and the abdomen closed without drainage

Resection.—A transverse incision starting from the right of the mid-line on a plane mid-way between the umbilicus and the anterior superior spine, and extending as far as the latter landmark, affords admirable access and heals well. The anterior rectus sheath is divided and the rectus muscle either retracted or partially divided, and the lateral abdominal muscles cut through with a diathermy knife. Enlargement of the mesenteric lymph nodes may add to the difficulty of division of the mesentery, but it is important not to attempt to remove them if by doing

so the risk of the procedure is increased. End-to-end anastomosis of ileum to transverse colon is to be preferred. If, however, there is indecision on the part of the surgeon as to whether hemicolectomy is to be done or not, it is a good plan to perform an end-to-side exclusion ileo-transverse colostomy, and to leave the decision about hemicolectomy until this stage is completed.

If haemostasis can be meticulously secured the abdomen may be closed without drainage.



Fig. 24.—Recurrence after ileo-transverse colostomy. Condition 4 years after operation upon a girl then aged 17 years with severe Crohn's disease with sinuses. The disease has spread from the ileum across the anastomosis to involve the colon. Hemicolectomy performed in November, 1952. Patient well except for microcytic anaemia which responds well to iron. (*By courtesy of Wallis Kendall.*)

TREATMENT OF RECURRENCE AFTER OPERATION

Generalizations as to the treatment of post-operative recurrence are of doubtful worth, and each case must be considered on its merits. Much depends on the nature of the original operation. If this was an exclusion operation (Fig. 24), the logical step in most instances would be to perform a hemicolectomy. If the recurrence is in the nature of a spread of the disease proximal to the anastomosis, the patient is virtually back where he was before the operation. In other words, the condition as it affects this particular patient is probably not amenable to surgical treatment. Re-operation should therefore not be contemplated before a determined trial is made of all available conservative measures, including radiotherapy. It is doubtful if a third operation is ever justifiable, although patients who have been subjected to multiple resections have survived in reasonable health (Garlock and his colleagues, 1951)

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ILEOSTOMY FOR ULCERATIVE COLITIS

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INDICATIONS FOR ILEOSTOMY

It is but rarely that ileostomy is undertaken for any condition other than ulcerative colitis; familial polyposis coli, Crohn's disease and multifocal colonic carcinoma are the rare exceptions. Since it is now usual to remove part or the whole of the large bowel at the time ileostomy is instituted, the technique is embraced by that of primary colectomy and primary panproctocolectomy. It is idle, therefore, to consider ileostomy in isolation though the very importance of the stoma justifies its special consideration. By the same token the indications for ileostomy are those for surgery in ulcerative colitis.

Haemorrhage from the colon

On clinical grounds alone recourse to surgery is necessary when a patient, *acutely ill, continues to deteriorate despite medical treatment;* also in the presence of acute complications such as severe and exsanguinating haemorrhage and perforation with widespread peritoneal soiling Emergency primary colectomy is an obvious requirement for haemorrhage since ileostomy alone will be ineffective. In these circumstances rectal excision is avoided since the patient's general condition will not permit the added trauma of dissection in the pelvis Nevertheless massive bleeding from the remaining rectal stump not infrequently ensues; it appears to arise from a generalized ooze rather than from erosion of a major artery, and an effective therapeutic measure has proved to be the instillation of 40 millilitres of adrenaline hydrochloride (1 in 1,000) and 5 millilitres of Stypven (Russell's Viper Venom) added to 500 millilitres of normal saline solution by slow drip through a catheter into the exteriorized upper recto-sigmoid stump This allows rectal excision to be postponed until it is practicable.

Perforation of the colon

Ileostomy alone is also ineffective as an emergency measure for perforation; it is impossible to close the area or areas of perforation, and drainage of these sites proves inadequate. Indeed, ulceration may progress despite deflection of the faecal stream and a patient has been seen who required colectomy 10 days after ileostomy

undertaken for a single perforation because massive haemorrhage then occurred owing to continued penetration of the bowel wall and erosion of the vasa recta in many areas. Ripstein (1953) was the first to show that colectomy under conditions of gross peritoneal soiling was surprisingly effective; his first 8 cases survived. Operation is best performed as soon as possible but cannot always be undertaken at the most propitious moment since the complication may develop silently in the clinical sense, without definite increase and localization of pain and without rigidity, general deterioration alone being apparent. Indeed, the presence of rigidity in ulcerative colitis is indicative more of an exacerbation than perforation, the reflex being brought into play by the inflamed colonic wall, as in appendicitis. Diagnostic confirmation of perforation is best obtained by radiological examination of the abdomen revealing air under the diaphragm. Perforation untreated is not necessarily fatal and the author has seen 4 cases within 2–4 days of perforation in whom localization was taking place by the time they came under surgical care; operation was then deferred.

Chronic (or intractable) disease with complications

Chronic disease more commonly constitutes the reason for surgery and the decision to operate then depends upon the patient's incapacity; should return to normal life appear to be unlikely under any other form of treatment surgery should be considered. Often other factors precipitate the decision, for those with chronic ulcerative colitis more frequently than not develop other complications such as anal fistulas, fissures, ischiorectal abscesses; or complications remote from the alimentary tract—arthritis, pyodermic lesions or erythema nodosum, and iritis, in that order of frequency. Recto-vaginal or recto-vulval fistula has been present in 19 per cent of the women who have come under the author's care; other anal lesions are more common, in particular fissure or frank ulceration extending below the ano-rectal ring and this is usually associated with a patulous sphincter and incontinence of faeces. Such ano-rectal lesions will not respond to the ordinary surgical measures locally applied, for with continued infection from above healing cannot follow excision. Remote complications such as arthritis (13 per cent) subside rapidly after removal of the bowel provided the condition has not persisted so long as to cause permanent changes in the tissue involved, in particular iritis and corneal ulceration call for early excision of the bowel since their effects can lead to serious incapacity from partial blindness within a short time.

Carcinoma is a gross hazard in the long-standing case but is not so hopeless as was once thought, though it is not uncommonly multicentric. Since these patients *are already passing loose motions containing blood and pus, the earliest symptoms* of carcinoma remain disguised; the onset of pain in a late case of ulcerative colitis is sometimes a sign of neoplastic change, and is of bad prognostic import since the pain is usually due to perirectal or pericolonic infiltration. The best results follow excision undertaken on the discovery of a stricture, for carcinoma frequently lurks unsuspected at a stricture since the growth may present none of the usual naked-eye appearances One patient has survived for 7 years following excision for carcinoma presenting as a stricture, and another for 5 (Fig. 25). The discovery by radiography of a stricture is therefore a sound reason for advising operation So also is the very fact of a long history without clinical evidence to

suggest malignant change, for this hazard appears to increase in proportion to the duration of the disease.

PRE-OPERATIVE MANAGEMENT

The moment for surgical intervention in the acute disease can be chosen only after continued observation; this raises the first principle in the management of ulcerative colitis—that physician and surgeon co-operate *from the time of admission*; under medical care alone there is a tendency for operation to be delayed until the patient's general condition has deteriorated to such an extent that the operative risk is greatly increased. Furthermore, it is impossible to predict with certainty the response to conservative measures; inevitably, therefore, the medical treatment applied to some patients will ultimately constitute pre-operative preparation.



FIG 25.—Stricture at the hepatic flexure, proved histologically to be due to carcinoma despite the absence of naked-eye appearances of malignancy.

Steroid therapy

This consideration has become more urgent since the advent of steroid therapy for the contra-indications to its use are far from universally recognized. Though effective when the disease is *limited to the mucosa, steroid therapy* is dangerous when the muscle wall has become involved It then appears to accelerate the process of disintegration so that the wall becomes thin, atrophic and atonic, and the bowel distends markedly, *more particularly in the transverse* colon through stagnation due to its dependent position Ultimately areas of bowel wall disintegrate completely, adjacent viscera or the parietes becoming adherent and thus providing substitutes for the bowel wall if free perforation has not already occurred. It has been suggested that potassium depletion may account for this atonic process but serum potassium levels are not consistently low in such cases; conversely, cases

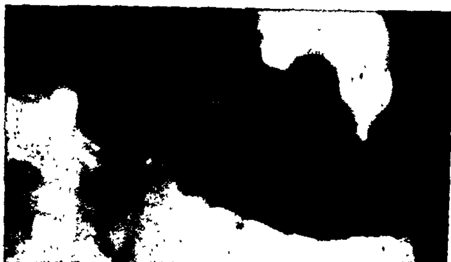
with serum values below 3·0 milliequivalents per litre occur without dilatation. Besides, hypokalaemia as seen in steatorrhoea or Crohn's disease causes a small-bowel atony but leaves the colon apparently undisturbed, whereas the colonic distension of ulcerative colitis is seldom associated with small-bowel changes of this nature. Moreover, histological examination of the bowel wall in ulcerative colitis reveals little if any normal muscle but only fibrous tissue, some degenerate



FIG 26.—Multiple collar-stud abscesses resembling diverticula in splenic flexure, descending and sigmoid colon.

muscle fibres and round cell infiltration—material in which contractility is inconceivable and the potassium mechanism is therefore inapplicable. The simple explanation is that the fabric becomes rotten due to ulceration advancing unchecked into the muscle, perhaps because cortisone prevents a proper inflammatory response in this layer and also deprives the tissues of the antibody response for protection against secondary invaders. The fully developed condition provides an urgent indication for surgery, for it denotes impending perforation. It can be recognized clinically by low central abdominal distension due to dilation of the transverse colon and is not infrequently associated with abdominal cramps. The colic together with the gross distension have deceived clinicians into the assumption that mechanical obstruction due to stricture is present; but stricture in ulcerative colitis only rarely causes obstruction because of the fluidity of the faeces. The colic arises owing to the difficulty encountered by the small gut in propelling its contents through the amotile reaches of colon ahead of it.

Careful inspection of the radiographs must be undertaken before instituting steroid therapy, to reveal any evidence that the muscle wall is being breached.



(a)

FIG 27 —(a) Barium enema revealing 2 collar-stud abscesses in transverse colon (b) Straight radiograph of abdomen following 6 weeks on cortisone showing gross dilatation, an indication of disintegration.



(b)



(*a*)



(*b*)



(*c*)

FIG 28—Barium enema (*a*) before and (*b*) after evacuation (*c*) Section of the transverse colon revealing the cause of the pseudo-haustration

Collar-stud abscesses may be seen as projections like small diverticula from the bowel lumen, more often in the sigmoid region but sometimes elsewhere (Fig 26) One alone is sufficient evidence that corticoids are contra-indicated (Fig. 27 *a* and *b*) An appearance resembling haustration is particularly deceptive since it is brought about by oedematous islands of mucosa regularly placed between areas of ulceration deep into the muscle layers (Fig 28 *a*, *b* and *c*). That the appearances are those of pseudo-haustration and are not due to haustration proper can be detected from the fine irregularity often to be seen at the edge of the pseudo-haustra and the fact that on screening they do not show movements of contraction and relaxation. Dilatation of any part of the large bowel, but usually of the transverse colon, constitutes a further contra-indication to corticosteroid therapy. All the appearances just described are also positive indications for bowel excision in that they present firm evidence of the extent of the disease process *in depth*; that ulceration has passed through muscularis mucosa and beyond; that repair is no longer possible. Dilatation may develop during the administration of corticoids and it is then a sign that not only should this therapy cease but also that excision has now become urgent since perforation is impending. It is wise to cease corticoid therapy when it has proved ineffective after 10 days'–2 weeks' trial, though this is not an indication *per se* to proceed to operation.

Psychological preparation

Once the decision to operate has been made it must be the first consideration to bring the patient to ileostomy rather than ileostomy to the patient. This is best achieved by dropping a word in season hinting at the possibility of surgery and the relief to be obtained thereby. As the patient's interest is aroused so a more detailed explanation is given with reference to the implications of ileostomy and its permanence, stress being laid on the fact that a full return to normal life is to be expected, for which a permanent ileostomy will be a small forfeit particularly when management has been mastered. At this stage a patient restored to normal health may be introduced, not only as an advertisement of success but also to answer any problems of management that may perplex the patient In this respect a local group of the Ileostomy Association (formerly known as Q T.) can assist greatly by organizing a visiting service.

Correction of biochemical defects

As regards physical preparation much will have been achieved by previous medical care but examination of the blood chemistry requires particular attention. Hypoproteinaemia and hypokalaemia are both refractory in the advanced case with much loss of fluid stool; diarrhoea can indeed be so persistent as to defy all attempts at their correction and under these circumstances, when the serum protein may be below 4 grammes per 100 millilitres and potassium 2·9 milli-equivalents per litre or less, operation is extremely hazardous. Sodium values are also likely to be low but restoration is easier to achieve; since sodium loss is the principal electrolyte problem following the institution of an ileostomy (Crawford and Brooke, 1957) a high dietary sodium is important before operation even when intravenous administration is not required

A final point for consideration arises if corticosteroids have been administered at some period. Careful inquiry should be made since patients who have been treated thus are particularly prone to post-operative collapse due to adrenal failure (Slaney and Brooke, 1957). Indeed, this may occur after as long an interval as 2 years following cessation of cortisone (Salassa and his colleagues, 1953). Collapse occurs quite suddenly within 12–24 hours of operation, unfortunately, no method exists whereby adrenal reserve may be assessed and in the absence of such a test either corticoid cover must be given over the operative period to all patients who have received cortisone or its analogues (Table) or especial vigilance must be maintained by the resident staff so that the condition may be treated as it arises. The prophylactic method has its disadvantages since all are thereby indiscriminately submitted to the risks inherent in corticoid therapy. Death from duodenal haemorrhage has been encountered, and so has post-operative septicaemia due to antibiotic-resistant staphylococci or *Clostridium welchii* Though it is desirable to avoid collapse of however short duration yet to treat the condition only when it arises does restrict the increased risks of steroid administration to those who need it. The decision must be a personal one, but if prophylaxis is chosen it is wise to maintain antibiotic cover with chloramphenicol.

TABLE

SCHEME OF CORTISONE AND CORTICOTROPHIN DOSAGE DURING OPERATIVE PERIOD

Day	*Cortisone (hydrocortisone where stated)*	*Corticotrophin*
0 − 2	Nil	20 u i m i b.d
0 − 1	50 mg i m i 6 p m	20 u i m i b.d.
0	50 mg oral 6 a m 50 mg i m i with premedication Post-operatively, hydrocortisone 100 mg i v by continuous drip in 12 hours	20 u i m i b.d
0 + 1	Hydrocortisone 150 mg i v by drip in 24 hours	20 u i m i b d.
0 + 2	50 mg i v by drip 12 noon, 25 mg 10 p m 25 mg.	20 u i m i b d
0 + 3	25 mg t d s	20 u i m i b d
0 + 4	25 mg b d	20 u i m i b d
0 + 5	25 mg	20 u i m i. b d.
0 + 6	Nil	20 u + 10 u. i m i
0 + 7	Nil	10 u b d
0 + 8	Nil	10 u
0 + 9	Nil	Nil

O, operation i m i, intramuscular injection. i v, intravenously All post-operative cortisone is given by mouth unless patient has ileus or some other complication Corticotrophin is given in an aqueous solution.

OPERATIVE TECHNIQUE

By far the most important feature in the surgical treatment of ulcerative colitis is the proper construction of an efficient ileostomy, and this outweighs any technical considerations relevant to the excision of the large bowel. Removal of the large bowel in whole or in part at the time of ileostomy has the advantage of providing a single stoma and resolves the difficulty of what to do with the distal ileal end when ileostomy alone is performed The operation of choice is primary panproctocolectomy which, by eliminating staged procedures, reduces mortality and morbidity. It must be emphasized, however, that the first operation on a patient with ulcerative colitis is the most dangerous (Brooke, 1956; Dukes and Lockhart-Mummery, 1957) and those who are severely ill may stand colectomy but not dissection in the pelvis. Two stages are therefore required for the more gravely ill—primary colectomy with exteriorization of the lower end of the colon where it is divided distally, and subsequent excision of the rectum. Although the author prefers to undertake primary colectomy if possible, there are occasions when ileostomy alone is all that a patient can sustain, the second stage is then panproctocolectomy.

There are few points of technique in the removal of the large bowel which require mention since it differs little from the summation of manoeuvres requisite for resection or excision of segments of the gut as for carcinoma; and these are well understood. Moreover, the procedure is easy except when the bowel wall has become friable and adherent as is sometimes seen following cortisone treatment. Then difficulties may become almost insuperable and mobilization is fraught with danger. Adhesion is most common to the parietal peritoneum across the paracolic gutter in the lower descending and sigmoid regions, less often in the caecum and ascending colon Attempts to detach the colon by defining a plane of cleavage between colon and peritoneum inevitably leads to entry into the lumen with disastrous soiling. The best course when the bowel is friable and particularly when it is dilated, is first to aspirate its contents by suction Closure of the hole necessary for suction must be undertaken before proceeding with dissection but this is difficult to achieve since stitches tend to cut out of the friable bowel and only serve to enlarge the opening It is therefore wise to place the opening close to the angle of attachment between colonic wall and peritoneum. Where the peritoneum is adherent it must be removed with the bowel, like a postage stamp adherent to it; an incision through parietal peritoneum to mobilize it is therefore placed at a slight distance from its attachment to the bowel and parallel to it. This leaves a small redundant leaf of peritoneum which may be sutured down over the hole made for suction, to act as a temporary covering; sutures placed from peritoneum through to bowel and back in mattress fashion usually hold firm.

Panproctocolectomy is best performed by 2 surgeons as a synchronous combined operation, and dissection in the pelvis is kept as close to the rectum as possible in order to preserve those pelvic nerve plexuses responsible for potency. The levatores ani are thus spared and can subsequently be sutured across the mid-line to support the pelvic floor, though this may account for the incidence of persistent perineal sinus which follows rectal excision for ulcerative colitis in contrast to the almost invariable healing after excision for carcinoma, because a triangular dead space is created posteriorly between the sutured pelvic peritoneum above, the levatores

below and the sacrum behind. To obviate this it has become the author's practice to leave the pelvic peritoneum unsutured and thus incorporate the dead space within the peritoneal cavity. It has long been general practice to leave uncovered with peritoneum the raw areas which remain after removal of the colon; it is common experience that these raw areas are soon covered with a shining membrane resembling peritoneum (Strauss and Strauss, 1944, Robins, Brunschwig and Foote, 1949), and doubtless the same obtains in the pelvis.

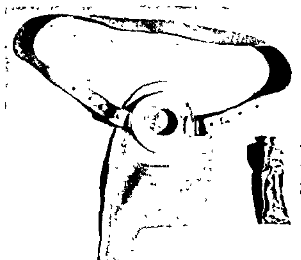


FIG 29 —Adherent ileostomy bag and cement (Salt & Son, Ltd)

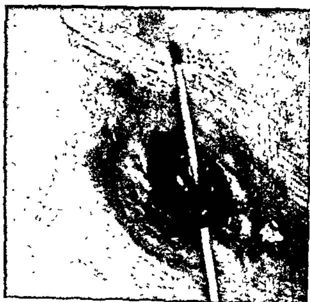


FIG 30 —Ileostomy fistula, note that the skin is excoriated and that the fistula is inferior

Construction of the ileostomy

Since the introduction of the adherent bag in 1944 (Strauss and Strauss, 1944) the method of construction of the ileostomy has become a matter of major importance for it must be designed to fit its prosthesis, the bag (Fig. 29) which has a flange providing a surface for adhesion. This flange must have adequate clearance from the groin, the iliac spine and the umbilicus to be effective, for otherwise it becomes detached The site which is to accommodate the ileal stoma should therefore be marked on the abdominal wall before the abdomen is opened and it is helpful to see the patient sitting in bed with hip flexed so that the situation of the fold of the groin may be noted, since this does not coincide with the furrow of the groin seen in full recumbency on the operating table. There is a tendency to place the stoma too low, an error which leads to subsequent chafing of the stoma by the flange of the bag with the production of a skin-level fistula (Fig 30) Another error is to make the stoma too short after its emergence through the abdominal wall and this accounts for the multiplicity of bags and devices to maintain firm application of flange to skin If the stoma is short it can be made to empty directly into the bag only by firm pressure of the flange against the skin, otherwise the ileal contents tend to trickle over stoma, skin and flange surface, and eventually between the skin and the face of the flange causing it to become unseated, producing incapacitating leakage and skin excoriation The stoma should ultimately be 2 inches in length, certainly not less than 1½ inches

An important development in ileostomy technique during this decade has been the realization that the serosa of the exposed ileum must be covered. Though skin grafts had been attempted prior to 1950, their purpose was to provide a stoma better adapted for the box employed for faecal collection in the era before the adherent bag Skin grafts have never proved satisfactory because of a high incidence



FIG 31.—Ileum withdrawn for constructing the stoma

of complications such as fistula and stenosis. The alternative was simply to withdraw the ileum, and under these circumstances the exposed serosa became covered with granulations until mucosa was gradually drawn down to the skin in approximately 2–3 weeks; fibrosis and stenosis replaced the granulations leading to stricture at skin level in 25 per cent of cases. In 1951 the author first undertook eversion of the mucosa in order to eliminate this stricture (Brooke, 1952; 1954) It is a simple matter to withdraw sufficient ileum from the abdomen so as to enable the terminal half to be everted or "intussuscepted" over the part immediately adjacent to the abdominal wall. It is difficult to state an exact measurement of the amount to be exposed since the ileal length varies considerably with its state of contraction, but when flaccid about 3 inches is the minimum (Fig. 31). A Duval lung-holding forceps is inserted into the lumen to a distance about half way along the exteriorized segment of ileum. A piece of ileal wall in its full thickness is grasped; this then acts as a fulcrum on which the distal segment can be turned back (Fig. 32), and becomes the stomal apex (Fig. 33) It is necessary to fix the position of the emerging layer to its covering layer for though the position of the ileum is assured as it leaves the peritoneal cavity by the fixation of its mesentery at that point, it is possible for the ileum distal to this to subside into the interstices of the abdominal wall, causing recession of the stoma There is only one point at which the position of issuing and returning layers may be fixed relative to one another and that is at the point where the edge of the mesentery of the issuing layer meets skin and is covered by the cut edge of the everted layer; one stitch is placed through all three structures (Fig 34) and thus the emerging ileum is fixed by its mesentery to the skin and is prevented from falling back into the stab incision Elsewhere the cut edge is approximated to the skin alone since sutures placed through serosa of the ileum cause fistulas The problem of stenosis has been solved thereby. Crile and Turnbull (1954) achieved the same end by removing serosa and muscle from the



Fig 32 —Manoeuvre of eversion



Fig. 33 —Eversion complete.

portion to be everted thus covering serosa directly with mucosa; they have also observed the elimination of serositis and consequent ileostomy dysfunction, characterized by colic with much fluid and electrolyte loss from the ileostomy occurring in the first few weeks after operation. Warren and McKittrick (1951) who described this condition encountered it in 130 of their series of 210 ileostomies. Thus eversion eliminates, in addition to stenosis, a common and serious post-operative complication which may be fatal, for 7 of Warren and McKittrick's 130 patients with this complication died

The site for the ileostomy is chosen at the beginning of the operation; eversion is undertaken at the end after closure of the main incision; an intermediate stage, after division of the ileum and withdrawal of sufficient of the proximal part through



FIG 34.—The stomal fixation suture is being placed

the stab incision to become the future stoma, is the fixation of the mesentery. Some surgeons prefer to trephine a hole through the skin rather than incise it, on the misconception that stenosis is thus avoided, it is, however, important to make relieving incisions at right angles to the main incision through the aponeurotic layers so as to avoid pinching the emerging ileum, but these should be no more than will permit the insertion of the tips of 2 fingers since recession of the stoma can occur through an opening which is too wide The cut edge of mesentery must be sutured across the para-ileal gutter in order both to anchor the ileum and thus preclude prolapse or recession, and to close a possible site of internal herniation and strangulation Suture of the mesenteric edge to the parietal peritoneum in its normal position is difficult and places too much tension upon the mesentery while at the same time kinking the small bowel, which it is important to maintain as free as possible since intestinal obstruction is the commonest post-operative complication. The difficulty is overcome by grasping the parietal peritoneum with forceps in the recess of the fossa, then drawing a ⅂-shaped fold towards the mesentery. The angle of the ⅂ is then sutured to the mesentery at the point where it

passes into the stab wound and to the peritoneal edge of the stab wound itself (Fig 35). This fixes the ileum in relation to the abdominal wall; it is appropriate, therefore, at this stage to ensure that sufficient length remains exteriorized before proceeding to completion of the sutures necessary to close the gutter, since retraction on the abdominal wall by the assistant may have caused encroachment upon



(*a*)



(*b*)

Fig 35 —(*a*) The first stage in closure of the para-ileal gutter—placing the fixation suture at the apex of the fold of parietal peritoneum (*b*) Key Rosette-like appearance—ileostomy loop Cross-hatching—parietal peritoneal fold Intervening space—mesentery

the length of ileum outside the abdomen Suture of the vertical limb of the peritoneal fold to the cut edge of mesentery is a simple matter as is closure of the slit formed by the horizontal limb lying against the parietal peritoneum of the anterior abdominal wall adjacent to the stab wound (Fig 36).

Ileostomy bag

A transparent polythene disposable bag (Fig 37) encloses the ileostomy when the patient returns to the ward, and enables the stoma to be watched for activity without

disturbance; a small supporting ring of wool around the stoma acts as a splint and so prevents the wall of the bag pressing the stoma into the abdomen during the 48 hours before its fixation by natural means becomes more certain. The stoma then becomes oedematous and not until the swelling has subsided is the permanent bag applied, for its orifice should fit the stomal base with accuracy, though not so close



(a)



(b)

FIG 36 —(a) The vertical line of sutures has been placed fixing parietal peritoneal fold to the cut edge of mesentery Two sutures have been placed laterally to start the closure of the horizontal limb (b) Key Rosette-like appearance—ileostomy loop Cross-hatching—parietal peritoneal fold Intervening space—mesentery

as to cause chafing In choosing an appropriate appliance simplicity is the first requisite; it is preferable that the flange should be pliable; too often the flange is reinforced or constructed of rigid material and convexly shaped so that it may be pressed deeply into the skin around the stoma This is undesirable since slight displacement may damage the ileum and cause a fistula necessitating operative revision; it is unnecessary if the stoma is of adequate length, and a pliable flange more readily adapts itself to the contour to which it must be attached. The author's preference is for a simple bag made in one piece (*see* Fig. 29) with a pliable flange since this type is slender and hardly perceptible under the thinnest clothing. It can



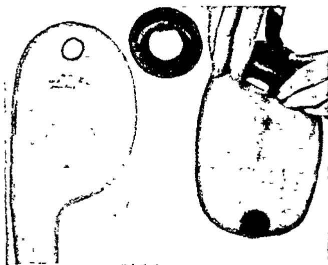


Fig 38 —Adherent bag with body detachable from flange (Down Bros.)

Fig 37 —The disposable polythene bag Double-sided adhesive is used for adherence ("Chiron"—Down Bros).

be detached from the skin for cleansing daily, though it will remain adherent for periods up to 1 week or more; the longer it is kept in position the less likely is the skin to break down Patients show considerable variation in the period they retain the bag in position, some wearing them for 3 days or longer, many changing them daily feeling this to be more hygienic Provided there is no associated odour the patient should be encouraged to keep the bag on as long as possible. The main alternative is the bag constructed in 2 pieces (Fig 38) with a flange separate from the body of the bag which is then detachable for cleaning. The increased thickness required at the flange is the only drawback since it makes the bag more bulky; also, if the stoma is short, clearance of the inner rim is not obtained and faecal soiling of the skin at the base of the stoma causes a small area to be constantly excoriated.

POST-OPERATIVE MANAGEMENT

The ileostomy begins to act usually within 24–48 hours; certain electrolyte problems then arise, in particular loss of sodium, and these are best anticipated before deficiency causes general deterioration—salt-depletion crisis, in particular, may present with sudden and profound collapse associated with peripheral circulatory failure. Whereas the more urgent pre-operative consideration is potassium loss, the problem changes to one of sodium loss post-operatively because in the initial period of activity the volume of excretion is high—from 1,000 to 3,000 millilitres with a loss of 150 milliequivalents per litre (Crawford and Brooke, 1957). Later the output drops; sodium balance can then be maintained by the patient without the ancillary aid of intravenous therapy though additional salt with the diet is advisable particularly during periods of increased ileostomy activity. Meanwhile potassium loss, which may have been as high as 80 milliequivalents daily or more in the diarrhoeic stools, is reduced to a constant output of about 10 milliequivalents per litre both from recent and established ileostomies. The output will, however, be raised and even remain as high as 30 milliequivalents per litre for 1–2 weeks if secondary ileitis has been present (Crawford and Brooke, 1957); this will fall as the inflammation in the terminal ileum subsides, as it will do even when the ileostomy has been sited in the affected segment (Brooke, 1956; Counsel, 1956). Any cause for true diarrhoea through the ileostomy will also increase the loss of potassium and must be borne in mind during therapy. The electrolytic situation appears to be improved in those patients on cortisone since, though sodium concentration in the ileal excretions remains roughly the same, the volume output is lowered; moreover, the combined loss from the stoma and in the urine is reduced without any appreciable rise in potassium output from these two sources. Other losses like nitrogen and calcium are not significant In the early stages when sodium losses are high, intravenous therapy is advisable as a routine to attain rapid adjustment. Should salt-depletion crisis develop it responds rapidly to twice normal saline solution, but this complication should not arise if due attention has been paid to output and allowance made for the normally high sodium losses.

COMPLICATIONS

Intestinal obstruction

The commonest early and late complication following ileostomy is intestinal obstruction. An important asset in the normal small intestine is its writhing movement, since this enables kinks to be unfolded and thus prevents a collection of wind or faeces becoming trapped at the bend of a loop Ileostomy itself fixes the small bowel at one point and usually some loops adjacent to it too are fixed by adhesions. Thus it comes about that approximately one-fifth of all cases suffer bouts of colic at some period from the fourth to tenth day as the activity of the intestine increases together with increase in its contents In most cases the obstruction corrects itself and the continued passage of small amounts of fluid constitutes a good sign that all will be well; the passage of a soft catheter into the stoma and the introduction of

50 millilitres of warm saline solution sometimes induces the more refractory case to return to normal function; but the continuance of colic without the passage of fluid or wind necessitates laparotomy.

Excoriation of the skin

Other complications of importance are all related to the ileostomy, and they mostly arise within 1 year. Excoriation of the skin has been common in the first 6 weeks following the institution of an ileostomy, but is now seen less frequently. Protection of the skin from the outset with the disposable bag minimizes its occurrence. Routine applications of silicone cream rubbed well into the skin facilitate adherence of the bag Should excoriation occur the application of a powder containing karaya gum is most effective, and changes may be rung with Baltimore (aluminium) paste and silicone cream. Excoriation always heals provided it is not due to continued soiling from a short stoma or a skin-level fistula, when only revision of the ileostomy will cure the condition. Rubber sensitivity develops rarely; it usually presents late, even up to 3 years after the institution of the stoma. When excoriation starts at a late date with no reason such as fistula to account for it, sensitivity tests should be undertaken against both the bag and the cement. If proved, the bag must be encased in linen when worn and the use of cement must cease. Should the stoma be long enough the bag may be pressed against the skin with the aid of a strong belt and leakage will not ensue; otherwise the problem is difficult, leading to incapacity from leakage.

Stenosis and fistula

Stenosis has already been mentioned; it is virtually eliminated by eversion and immediate mucocutaneous suture. Fistula will arise if stay sutures are placed through the seromuscular layer of the emerging layer of ileum; this is now well appreciated and therefore is seldom seen. The more usual cause arises from chafing of the bag against the stoma when the thigh is flexed; the stoma has then been placed too low and the condition calls for resiting of the ileostomy.

Prolapse

Prolapse is another complication which is becoming rare now that proper fixation of the mesentery within the abdomen by closure of the para-ileal gutter is undertaken in most centres. Occasionally the mesentery becomes detached as the patient puts on weight (non-absorbable sutures should always be used), and prolapse may follow. It is wise, therefore, to inspect the para-ileal gutter at any subsequent operation in a staged excision of the bowel

Recession

Since using the eversion technique recession has been more frequent; it has been due to one of several causes—detachment of the mesentery, retraction by adhesions, or relapse into the interstices of the abdominal wall or through too large a stab wound The cause can be diagnosed and corrected only by full revision through a laparotomy incision.

RESULTS OF OPERATION

It is not possible to present operative mortality figures for ileostomy *per se* since ileostomy is commonly associated with excision of the large intestine either in part or in whole. The patient mortality has fallen from 22 per cent for the period 1928–46 to 5 per cent in the years 1947–52 at the Lahey Clinic (Cattell, 1953; Cattell and Colcock, 1955) the operative mortality being 13·7 per cent and 2 per cent respectively, while at St. Mark's Hospital the operative mortality has fallen from 8 per cent to 2·7 per cent (Dukes and Lockhart-Mummery, 1957). In the author's series ileostomy and excision has been achieved in 302 operations for 188 patients with 16 operative deaths, an operative mortality of 5 per cent and a patient mortality of 8 per cent which rises to 11 per cent with the inclusion of late deaths from such causes as intestinal obstruction, carcinoma and lung abscess Included in these figures are 12 patients for whom ileorectal anastomosis was performed, in 5 of whom the anastomosis has already been replaced by a permanent ileostomy with excision of the retained rectum.

In order to assess the capacity of those living with an ileostomy 101 patients were interrogated by questionnaire at the end of December, 1955 (Brooke, 1956); 92 were at full work, 7 were convalescent and 2 were doing no work through blindness following iritis, 1 having arthritis in addition Five patients did not regard the ileostomy as satisfactory, though they were not prevented from following full employment; 11 patients who considered the ileostomy to be satisfactory suffered slight or intermittent excoriation Most patients were able to follow pastimes of their choice, such as swimming, dancing and tennis. The limitation in activity experienced by 34 patients was due to discomfort on stretching or bending, and sometimes when lifting heavy weights, 7 others were still convalescent. Approximately half the patients restricted their diet, most because fruit skins or pips formed an indigestible bolus causing colic as it reached the indistensible ileostomy stoma; some found that fruit juices, green vegetables or salads caused the motion to become fluid, others avoided a large meal in the evening since this might so fill the adherent bag during the night as to require its evacuation; 6 patients were dieting in order to reduce an embarrassing increase in weight (4 stone 7 pounds to 12 stone 8 pounds; 8 stone to 15 stone) It is worth noting that the results remained satisfactory in those patients treated 5 years or more previously, 5 of whom had lived with an ileostomy for 10 years or longer.

The fear has been expressed (Dennis, 1945) that removal of the rectum might lead to impotence in the male; specific inquiry on this point has shown the fear to be ungrounded, though it has not been possible to put the question to every male patient. Four women have gone to term and breast fed their babies after normal labour, without complications to the ileostomy; one of them has had 2 normal pregnancies.

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ABSTRACTS RELATING TO THE ABDOMEN

THE STOMACH AND DUODENUM

Carcinoma of the stomach

ABO blood group

TURUNEN and PASILA (1957) discussed the ABO blood group and carcinoma of the stomach. A study has been made of 990 patients, of whom 613 were men and 377 were women; the cases were collected from 4 different [illegible]

[illegible]

whole population the authors assume the existence of a genetic correlation between the blood groups and the anatomy and physiology of the antrum.

Lymphatic spread of gastric cancer

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bloc removal of the great omentum, total gastrectomy, total ...
and splenectomy; the coeliac nodes of the
consisted of removal of similar tissues, exc
per cent, and the duodenum was left intact. The fresh specimens were perfused with sodium citrate, fixed with formalin and dehydrated; the lymph nodes were then removed and prepared for microscopic examination with haematoxylin-eosin stain. To identify the anatomical location of the removed lymph nodes, 9 areas were designated; the nodes of the left gastric chain were found to be most commonly ...
area of involveme
artery. Specimens c
68 out of 73 nodes; the lowest was 1 positive node out of 37 isolated; the 2 most undifferentiated tumours had the highest incidence of lymph node involvement. The splenic chain nodes were involved in 5 out of 7 specimens: in 4 out of 5 instances, adequate removal of these nodes necessitated ligation of the splenic artery at its origin from the coeliac axis and complete removal with its attendant nodes and connective tissue; 6 out of 7 specimens demonstrated the need for careful excision of "coeliac axis" nodes. The anterior and posterior pancreaticoduodenal nodes were not involved in any of 5 specimens examined. The study demonstrates that lymphatic spread cannot be reliably predicted from the location of the primary lesion. These operations failed to benefit any of the patients. the immediate hospital mortality was 75 per cent and the 2 patients who left hospital after operation died within a few months from recurrence of cancer; total gastrectomy combined with total pancreaticoduodenectomy does not appear to be a satisfactory procedure for cancer of the stomach.

Total gastrectomy

HERTER and AUCHINCLOSS (1957) discussed total gastrectomy in 91 cases, 88 of which were large advanced tumours incurable by less extensive resections. Of 83 malignant growths, 43 per cent involved the entire stomach, 20 per cent the upper or lower two-thirds; in 17 cases only the upper third was implicated. In 6 tumours of the linitis plastica type, the degree of node involvement made total gastrectomy imperative. Gross or microscopic lymph node involvement occurred in 67 patients, direct invasion of contiguous ... performed

side oesophagojejunal anastomosis of the Roscoe-Graham type, a long side-to-side jejunojejunostomy being effected immediately below the oesophagojejunal anastomosis In 3 cases a duodenojejunal anastomosis was performed. In 14 cases an end-to-end ... below the ligament of ... ig operations represent ... to obtain early mixing ... stric pouch was created ... 2 groups, those ... is a significant ... earlier group, ... echniques and
antibiotic therapy, in ... Of the first
group, 22 survived ope
7½ years and can be c
but, in the first year,
nutritional aspects are difficult to assess, but limited weight gain was fairly consistent. Digestive symptoms occurred in 77 per cent of cases, the commonest being prandial or postprandial pain located substernally or in the epigastrium. The symptoms followed

every method of reconstruction except direct oesophagoduodenostomy, but diminished in time. "Dumping" was rare. Total gastrectomy is not advocated for well-localized small lesions; these are adequately excised by the high subtotal operation Pyloric or antral lesions with spread to the retroduodenal lymph nodes suggest radical pancreaticoduodenectomy, combined with either total or subtotal gastrectomy.

Gastric ulcer

Modified Billroth II and incidence of carcinoma

In a discussion on the surgical treatment of gastric ulcer STRODE (1957) reported on the use of the Billroth II operation, modified by the technique of Polya–Hofmeister and

resection was carried out, but the pathologist examined a number of sections of the wall of the ulcer and eventually discovered a small area of carcinoma It was evident that an accurate diagnosis could not have been established in this case by using techniques such as fluoroscopy, gastroscopy or cytological studies

Peptic ulcer

Acute perforation

the risk of death increases as the time interval between perforation and operation increases and that the risk is greater in older patients. The 6 patients who were treated conservatively were neglected cases in which over 48 hours had elapsed since the perforation: they were treated by nasal gastric suction, there were 3 deaths among these cases. A comparison of mortality and sex demonstrated that men had a total mortality of 9·9 per cent

... of 12 cases; the high female mortality is due ... more than 12 hours after ... in 48 cases, with a mortality ... per cent, the antrum in 88 ... lization was unknown had a

Haemorrhage

... account of the findings in 73 patients ... case acute haemorrhage was associated with either a haemoglobin ... per 100 millilitres or acute hypovolaemic shock, pallor, cold skin, sweating and a systolic blood pressure which was not greater than 90 millimetres of mercury. With regard to treatment, the ... anthelytic drugs. Feeds were administered at ...

... duodenal ulcer and 4 cases of gastric ... patient was aged more than 60 years ... of peptic ... duodenal ... associated ... in the ...

that surgery should be employed ... age of 60 years, especially when the blood type is AB or B, Rh negative ...

... presented by Walters ... patients, with an operative mortality of 1.7 per cent ... cent and suspected in an additional 1.6 per cent of the cases, the sex incidence ... essentially similar except in cases of gastric ulcer, among whom all 4 patients with proved ... excellent or good functional results were obtained in 92 per cent of ... additional 2 per cent continued to experience ... he percentage incidence of ... the incidence of proved ... but in cases of duodenal ... series; it is emphasized, ... of the limited use of the ... of gastrojejunal ulcer in ... the Billroth II operation, ... infrequently to allow com- ... among cases of combined ... uting was slightly more ... be established, and the ...

Partial gastrectomy

Primary and late results.—VIIKARI and KLOSSNER (1957) recorded the primary and late results of 1,050 partial gastrectomies for chronic gastroduodenal ulcer. The series comprised 898 men and 152 women; of the 1,050 patients 470 had gastric ulcer and 580 had duodenal ulcer. The operation was performed according to Billroth II: in 14 cases retrocolic anastomosis was created; in 44 per cent of the duodenal ulcer cases the exclusion

Observations made 1–11 years post-operatively showed that out of 924 patients 68 had died, 6 of whom died from gastric cancer: 18 patients, all males, had recurrent ulceration;

authors recommend vagotomy and re-resection in cases of gastrojejunal ulcer; pylorectomy should be performed if the antral part remains.

Postgastrectomy dumping syndrome

Pathogenesis

Distension and hypermotility.—JORDAN, OVERTON and DE BAKEY (1957) reviewed the

continuity had been re-established by gastroduodenostomy in 5 patients and by gastro-

Distension of efferent loop.—AMDRUP and JORGENSEN (1957) recorded further investigations on the pathogenesis of the dumping syndrome, with special reference to the role of

distension of the efferent loop. The results of experimental work have demonstrated, in all cases, a fall in plasma volume, occurring simultaneously with the dumping attack; the most prominent symptoms of the syndrome can be readily explained by the often considerable reduction in the circulating plasma volume. The dumping attack, in the ... experiments was provoked by a hypertonic glucose solution administered ... when the solution runs too ... supine position the ... in the small

... into the intestine for dilution of the ... introduced into the efferent loop, in 3 patients who ... ymptoms, did not produce dumping attacks or any ... ngestion of a 50 per cent glucose solution in the same ... and fall in plasma volume. The authors have ... lucose solution in ... ms); intravenous ... ects was followed ... tissues occurring parallel to the ... is because the concentrated solution is slowly distributed over the ... and is diluted by ... and only a very small quantity of fluid diffuses into the intestinal ... is rapid over a large ... ugh distension ... , it does not by itself cause any of the general symptoms.

... Billroth II for peptic ulcer

... which severe symp... esection in ... meals, the ... ating and a ... with reduction in the plasma ... flow and a rise of 4 centigrade degrees in the skin temperature. The ... aphic tracing showed cerebral dysrhythmia. Two months after the second operation the reduction in plasma volume after a test meal amounted to only 250 millilitres and there was only a slight increase in the peripheral blood flow and in the skin temperature. No symptoms of dumping were experienced after the test meal and the electroencephalogram showed normal tracings.

Complications of gastrectomy

... ration ... the use of a long afferent ... ical treatment of peptic

ulcer is highly successful complications may occur associated with the use of the long

not develop for months or

account for the vague an

contents. Removal of the loop and reconstitution to 10–15 centimetres relieved both patients

Haemorrhage

WILKINS, ROGERS and STRAEHLEY (1957) discussed severe haemorrhage following

feasible, a duodenal ulcer should be removed with the resected duodenum Conservative treatment consists of blood transfusion, continuous gentle lavage and suction and complete decompression of the stomach pouch to allow collapse of the vessels Cantor's

Unusual complications of subtotal gastrectomy

STUART and JORDAN (1957) reported 5 cases illustrating unusual complications of subtotal gastric resection The first 2 were men with ulcers on the lesser curvature near the oesophagogastric junction, in the second, the ulcer was within a hiatus hernia. The first patient developed, post-operatively, small-bowel obstruction compromising its blood supply. Exploration revealed necrosis of the gastric remnant and a large subphrenic abscess. Post-operative peritonitis in the second patient also necessitated exploration, which showed the gastric remnant and the 2 gastroenterostomy limbs to have rotated nearly 180 degrees Both patients died. These cases emphasize the serious results of

pancreatitis. Improvement occurred after cholecystostomy but fatal intra-abdominal haemorrhage ensued. The inflammation associated with the ulcer had resulted in duodenal shortening, and, as a result of this, closure of the duodenal stump occluded the ampulla of Vater and this obstructed the common bile duct and duct of Wirsung. The drainage of these ducts into the peritoneal cavity produced necrosis, haemorrhage and death. Millbourn (1949) has stated that the more superficial duct of Santorini is more vulnerable in these cases than the duct of Wirsung and the consequences of injury equally serious.

Pulmonary tuberculosis following gastric resection

FRUCHT, KUNKEL and SPIRO (1957) discussed pulmonary tuberculosis following gastric

to gastric surgery and those due to tuberculosis. One patient gained 15 pounds after operation; 1 remained stationary and 9 lost weight. In 3 patients there was evidence of pre-existing tuberculosis. In 1927 Winkelbauer and Frisch gave warning of tuberculosis following gastrectomy, but their paper escaped attention and it was not until 1942 that ... Since then many others have been reported. The most com-
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tuberculosis follows gastrectomy. Confusion has arisen between exacerbation by surgery

OPERATIVE CHOLANGIOGRAPHY AND MANOMETRY OF THE BILIARY TRACT

Biliary dyskinesia

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17 cases exploration was performed because the radiographs were unsatisfactory. In 16 cases the interpretation of the cholangiogram proved to be erroneous. On 6 occasions exploration of the common duct yielded stones after a negative radiographic report had been issued. Other errors were due to misinterpretation of spasm and gas bubbles, technical difficulties, extravasation of the opaque medium and incomplete filling of the biliary apparatus. The authors express the hope that, with improvements in technique, it may be possible in the future to avoid many unnecessary explorations of the common bile duct. The results are likely to be improved by the use of better apparatus, by ensuring proper placement of the cassette, and by co-operating with the anaesthetist in order to secure apnoea during the period of radiological exposure.

Value and limitations

CORFF (1957) was of the opinion that operative cholangiography should be employed in every case in which the common bile duct is explored. As yet, however, it cannot be said that the method of investigation has reached perfection. Moreover, circumstances sometimes arise which are beyond the control of the surgeon. For instance, it may not be possible to remove an intrahepatic stone during the operation, and subsequently the stone may drop into the common bile duct, where it is observed on post-operative radio-
...omy type of cholangiography is often an aid
... the management

(28 per cent of cases). Stones in the common duct were found in 47 per cent of the whole series and in 50 per cent of the cases with jaundice. It was of interest to note that 27 per cent of the patients had stones in the duct but showed no signs of jaundice. Post-choledochostomy cholangiograms revealed that stones were still present in 5 per cent of the 81 cases in whom it was performed despite surgical exploration of the common duct. In these cases the duct was reopened and the stones were removed. Pre-choledochostomy films yielded inaccurate results and were not considered to be reliable, for with these ... reports.
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even after the cholangiograms were taken. Among this group there were ... re reports and 3 indefinite reports. In 2 instances no post-choledochostomy films were obtained. Corff believes that under ideal circumstances the incidence of retained stones might have been reduced to 2 per cent.

CROHN'S DISEASE

Evaluation of current management

BARGEN (1957) presented an evaluation of the present-day therapeutic management of regional enteritis. Experiences with surgical treatment have shown that surgery is not indicated for all cases and as a result the outlook has become more conservative so that patients are now usually treated medically. Although treatment is not remarkably satisfactory, certain measures have been found helpful. The cases may be divided into two categories: those which do not exhibit complications and those which do; even when ... perforation, obstruction, and the
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secondary deficiency syndrome resembling sprue, and in those with secondary uveitis, arthritis or pyoderma Although the recurrence rates after surgical treatment are high, the survival rates also are high; at the Mayo Clinic the 10-year survival rate was 81·1 per cent.

Indications for surgical intervention

CROHN (1957) discussed the indications for surgical intervention in regional ileitis. The author knows of no adequate and satisfactory conservative method of therapy for

for surgery comprise: (1) localized regional or terminal ileitis; (2) fistulas to the abdominal wall; (3) perirectal fistulas, (4) haemorrhage, (5) intestinal obstruction, (6) recurrent ileitis; (7) persistent activity in primary lesion after attempted short-circuiting procedure; (8) perforation. An irresolute "marking-time" prolongs the painful and debilitating

with rotation and obstruction, in very rare instances The true rate of recurrence after surgical intervention is difficult to estimate, although some investigators distinguish between "clinical" and "radiological" recurrence, the author considers that radiological signs of recurrence are followed sooner or later by clinical symptoms.

ILEOSTOMY FOR ULCERATIVE COLITIS

Ulcerative Colitis

Pathology and surgical treatment

Practical points in the pathology and surgical treatment of ulcerative colitis were discusse[illegible]
advanc[illegible]
in the [illegible]

are liable: a late mortality of 3·2 per cent is reported, the majority of the deaths being due to intestinal obstruction; prolapse, retraction and other complications can be minimized by careful operative technique and post-operative management; rehabilitation of the

only by close co-operation between physicians and surgeons and it seems probable that only in this way can real progress in the surgical treatment of the disease be made.

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MALIGNANT DISEASE OF THE THORACIC AND ABDOMINAL OESOPHAGUS

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Ten years ago the surgical treatment of cancer of the thoracic oesophagus was being carried out by a relatively small number of surgeons who were striving to improve their methods and develop new ones. Today, as a result of this earlier work, many more surgeons are undertaking the difficult and exacting operations required for patients suffering from this disease. There is over the same period one other notable change which has come about, and it relates to the field of radiotherapy. In 1948 there were available only conventional 250 or 400 kilovolt x-rays and intralumenal radium as methods of irradiation. Today, there exist megavoltage x-rays and radioactive cobalt in large units with refinements of beam application not previously available. It is for these reasons that a critical survey of all the methods available would appear to be timely. In a previous survey, Robertson (1954) pointed out the necessity for a sincere effort to select the technique best suited to the individual patient and such selection should include radiotherapeutic as well as surgical methods.

PATHOLOGY

The commonest form of malignant disease in the oesophagus is a squamous-cell carcinoma; adenocarcinoma when it appears must have arisen either in the mucous membrane of the stomach or, much more rarely, in rests of gastric epithelium higher up in the gullet wall. Nevertheless, it would be quite wrong to exclude cases of adenocarcinoma since they constitute a large part of the problem, present with the same symptoms, may extend to a surprising distance up the [illegible]

author's personal series, all the patients in which came with dysphagia as one of their main troubles, if not the presenting symptom.

The squamous-cell cancers may occur anywhere in the length of the gullet and form a considerable proportion of those occurring at the cardio-oesophageal junction. They most commonly take the form of a typical malignant ulcer extending through and beyond the muscular wall of the oesophagus for varying distances. In some cases there is considerable stenosis; less commonly there is so much excavation that the oesophagus is actually widened, but despite this the infiltration and consequent interference with the musculature causes equally serious dysphagia. Papillary and fungating growths are less common, but can cause severe obstruction and tend to bleed more readily at oesophagoscopy.

TABLE I

TYPES OF MALIGNANT DISEASE* INVOLVING THE OESOPHAGUS

Squamous-cell carcinoma	55
Adenocarcinoma of gastric origin	39
Metastatic cancer (breast)	5
Direct extension from bronchus	2
Leiomyosarcoma	1
Total	102

* Two cases of benign leiomyoma occurred, one at the level of the aortic arch, the other just below cardio-oesophageal junction

Adenocarcinoma of gastric type is most often found at the lower end of the oesophagus but may be seen at a much higher level. This can be due either to submucous or perioesophageal spread of the cancer or to the fact that the oesophagogastric junction is abnormally high in association with a hiatus hernia, a state of affairs which is by no means uncommon.

The present series of cases shows what may be thought to be an unreasonably high incidence of metastatic cancer of the breast occurring in the oesophageal wall, but this is probably due to the very large number of breast cancers treated in Westminster Hospital and radiotherapy centre The oesophagus as a site of breast cancer metastases has been noted by others When it occurs the metastasis is usually submucosal and not ulcerated and it may be difficult or even impossible to get a "bite" from it with the biopsy forceps.

Extension of carcinoma of the bronchus causing dysphagia is very well recognized and it is important that the diagnosis should be made early on as decisions relating to treatment are dependent on it.

Leiomyosarcoma is a rarity; the one case in this series occurred at the cardio-oesophageal junction

Whether the disease be squamous-celled or adenocarcinoma, once it has involved the oesophagus it tends to spread longitudinally by direct submucous extension and also via the lymphatics in both upward and downward directions. Spread by direct continuity to the mediastinum, lung, and bronchus is common but, in the author's experience, direct involvement of the aorta or pericardium occurs only very late in the disease. The disease metastasizes most commonly to lymph nodes, liver, and lungs in that order.

DIAGNOSIS

In the majority of cases the symptoms and radiological examination by barium swallow are sufficient to establish a firm diagnosis, but there are a number of patients about whom doubt may still exist. In these latter cases, or where dysphagia persists for more than 2 or 3 weeks in the presence of a normal barium swallow, oesophagoscopy is imperative. Moreover, in the author's opinion it is quite wrong to operate on a patient with a diagnosis of cancer of the oesophagus without, as a preliminary, examining the state of affairs endoscopically and performing a biopsy. The latter establishes the diagnosis beyond all doubt and indicates the origin of the growth when positive, and if negative merely indicates the necessity for further thought and search. Most surgeons prefer to perform oesophagoscopy with the patient under a general anaesthetic and the opportunity should then be taken to carry out a bronchoscopy at the same time. Broadening of the carina, or stenosis of a bronchus, are important indications that the growth may be unresectable. A number of these patients have bad dentition and gross oral sepsis, and where indicated the necessary extractions should be done in order to eradicate this unpleasant source of sepsis

In addition to these manoeuvres it has been suggested that where facilities exist the patient should at the same session be examined with a peritoneoscope. If hepatic or peritoneal metastases are seen it may well alter the surgeon's plan of management.

Oesophagoscopy

Oesophagoscopy is a procedure which is not devoid of danger even in skilled and gentle hands. Perforation or damage to the wall of the oesophagus can occur in 2 quite different ways

In some patients the damage is caused by the posterior oesophageal wall being crushed or split by pressure between the back of the oesophagoscope and osteophytic "beaking" of the anterior aspect of the bodies of the cervical vertebrae. This is well shown in Fig 39 where gas shadows indicate the site of a retropharyngeal abscess Such an accident usually happens only when the patient has, as well as the "beaking" referred to, large upper incisor teeth. The removal of these may be necessary before the oesophagoscopy can be safely accomplished.

The other way in which the gullet is perforated is either by the beak of the oesophagoscope or by a bougie which either perforates the wall at some point or splits the malignant segment This can happen without the operator being conscious at the time of the damage he has caused, since the wall of the gullet is frequently softened by hyperaemia due to the oesophagitis associated with the obstruction and the fermentation of retained food residues.

Whichever mechanism is responsible for the damage, the result is usually a complaint by the patient of increased dysphagia and pain A rising pulse rate and pyrexia increase suspicion, and radiological or clinical evidence of air in either the pleura, mediastinum, or other tissue planes puts the diagnosis beyond question.

Where such suspicion is aroused in a patient with a carcinoma of the oesophagus, it is in the author's opinion imperative to proceed immediately and as a matter of urgency to oesophagectomy. It is of no use arguing that this is a big

operation and that the patient has not been properly prepared, or hoping that the situation may improve. It will, if distal obstruction is present, inevitably deteriorate and delay can only lead to the optimum opportunity being lost. The patient is in a position similar to, but much more serious than, the patient with a perforated gastric ulcer. The author has had 2 such cases of instrumental perforation of the oesophagus which were treated by immediate oesophagectomy with a convalescence gratifyingly free from anxieties or complications. Other cases are recorded by Blalock (1957).



FIG. 39.—Gas-containing retropharyngeal abscess. Note the anterior "beaking" of the vertebral bodies, and the compression of the oesophagus.
(By courtesy of the Editor, Annals of the Royal College of Surgeons of England.)

Only where there is doubt as to whether a perforation of the oesophagus has occurred in a patient in whom there is no distal obstruction is it justifiable to await the course of events In these circumstances conservative treatment by forbidding oral intake, instituting intravenous feeding and giving antibiotics may have a favourable outcome

PRE-OPERATIVE PREPARATION

Many of these patients are in a pitiable state when they first present at hospital. Fear, neglect, stupidity, and at times even bad doctoring contribute to delay in diagnosis with a consequent poor state of nutrition. A week or two spent on the correction of this state is of the utmost importance and benefit. The correction of oral sepsis, dilatation of the malignant stricture, prohibition of all solid food especially fish, which seems to have a particular ability to obstruct, and provision

of an ample fluid diet of high calorie and protein value with added vitamins, will do much to improve both physical condition and morale of the patient. At the same time breathing exercises should be instituted.

OPERATIVE TREATMENT

Before proceeding to discuss the details of the various operations available for malignant obstruction of the oesophagus, it is necessary to consider what it is that one intends to accomplish and what the chances are of achieving such intentions. Obviously one would like to "cure" the patient, but this implies the removal not only of the lesion but also of a wide area of normal tissue around it together with the immediate lymph node drainage area, all this *en bloc*. Having regard to the anatomy of the oesophagus as it lies in the mediastinum closely surrounded by other important structures, it is unlikely that the surgeon will be able to achieve so good a clearance as he would wish. Put in another way, this means that operations for resection of cancer of the oesophagus are often likely to be only palliative in that they remove the cause of the patient's symptoms but are apt to be followed by recurrence of disease, either local or distant, at an early date. Moreover, because of the difficulties of pre-operative assessment of the degree of spread of the malignant process, it may prove at operation to be physically impossible to resect the lesion. In these circumstances it is in the author's opinion the duty of the surgeon still to attempt some manoeuvre which will restore to the patient the ability to swallow, such by-pass operations being truly palliative. In yet other patients the obstructing lesion may be readily removable though the case is inoperable, in the strict sense of the term, by reason of metastases in, say, liver or lung: in such circumstances the primary lesion should always be removed and continuity restored.

The restoration of continuity of the gullet at the same operation as that which removes the growth is the hallmark of modern surgical treatment and it would seem unnecessary to comment on this aspect were it not for reports still appearing of work where the old Torek type of operation is done with subsequent reconstruction procedures (Petrov, 1957). If more than one step is required in this process it seems to the present writer that the new gullet should be established first, thus enabling the patient to improve his nutritional state before the excision is carried out, say, 3 weeks later.

Following on the work of Behrmann, there have been many attempts at the use of various prostheses, grafts, and so forth, to overcome the difficulty of restoring continuity especially in the patients with the higher situated growths, but most workers have found them unsatisfactory and with a high incidence of leaks and consequent mortality and morbidity (Abbey Smith and Raison, 1957). Nor, if such methods are used in order to effect greater clearance from the disease, is the salvage rate improved as was shown by Mason Morfit, Klopp and Neerken (1957).

If it is agreed that prostheses, aortic grafts, and antethoracic plastic reconstructions are not acceptable, there are left but 3 structures available for the reconstruction, namely, stomach, small intestine, and large intestine.

Of these the stomach has been most widely used and is the obvious and proper choice in most cases. It is only when the growth lies high in the oesophagus,

necessitating a cervical section of the gullet, that the stomach may not be a practical possibility as a substitute. Though in many patients it will reach as high as the neck, the stomach cannot be relied on always to do so and then some alternative is required. The upper small intestine is the structure which comes most readily to hand and will in most cases provide a sufficient length to pass through an anterior mediastinal tunnel to reach the neck (Robertson, 1954).

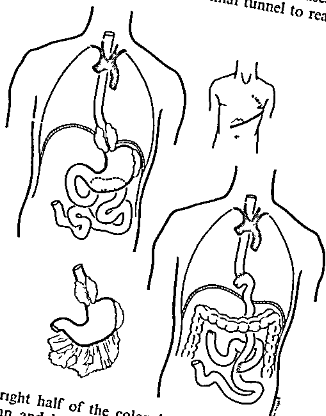


FIG. 40—Diagram of abdominothoracic resection of cancer of lower end of oesophagus, together with the whole stomach. Restoration by oesophagojejunostomy. (*By courtesy of the Editor, Annals of the Royal College of Surgeons of England.*)

The right half of the colon has also been used to furnish a new oesophagus (Sherman and his colleagues, 1955), but there are certain drawbacks to its use, the most obvious being the septic nature of the gut content at that level and the necessity therefore of extensive preparation. When used, it is usual to pass the caecal end up to the neck, the transverse colon being anastomosed to the stomach; the whole loop is dependent usually for its blood supply on the middle colic artery.

There are certain operations which have become fairly well established as "routine" procedures for cancer of the oesophagus at different levels. Because the growths at the lower end are commoner and because the lower operations were evolved first it is proposed to deal with the operations as they refer to increasingly higher lesions.

The abdominothoracic operation

This operation (Fig. 40) is used for lesions affecting the cardio-oesophageal junction and particularly when it is known or suspected that the stomach is extensively involved, thus calling for a total gastrectomy with resection of a

reasonable length of oesophagus. A long oblique incision in the line of the seventh left rib and continued downward across the abdomen allows that cavity to be opened for preliminary assessment. If it is decided to proceed, the seventh rib is resected, the costal cartilage cut across, and the diaphragm divided down to the hiatus. It is then possible to mobilize the whole stomach, great omentum and, if desired, the spleen, and tail of the pancreas These two structures are removed

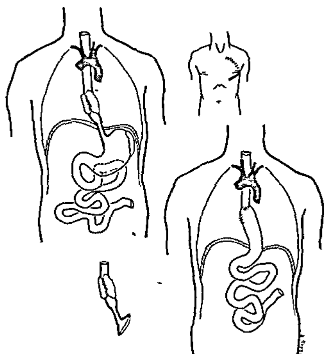


FIG. 41.—Carcinoma of the lower oesophagus. Partial oesophagectomy and oesophagogastrostomy through a left thoracotomy.

(By courtesy of the Editor, Annals of the Royal College of Surgeons of England)

since much of the lymphatic field lies behind and around them as was shown by Allison and Borrie (1949) The duodenal stump is closed, and restoration of continuity is obtained by performing end-to-side oesophagojejunostomy to a Roux loop of jejunum. End-to-end anastomosis can of course be performed but is technically a little less easy and, because of the arrangement of the mesenteric vessels, does not allow of so much length as the end-to-side method.

This is a big operation and throws a considerable strain on the patient in the immediate post-operative phase when coughing is more than usually painful and difficult. Furthermore, the late nutritional state of these patients often leaves much to be desired and some may be described as semi-invalids. It is for this reason that the author has tended to reserve this operation for the younger more vigorous patients in whom an early lesion is expected and where the prognosis is therefore relatively more favourable. He believes it is wrong to perform this very extensive operation where there is any doubt about the complete eradication of the disease in the macroscopic sense. In such circumstances a more limited resection will relieve the patient's symptoms and leave him better able to maintain his nutrition.

Partial oesophagectomy through a left-sided thoracotomy

This is the operation (Fig. 41) most commonly performed for lesions situated in the lower two quarters of the oesophagus, or for lesions of the gastro-oesophageal junction when, for reasons already mentioned, a more restricted operation is thought to be advisable. The approach is usually made by resecting the sixth or seventh rib.

The pleura over the oesophagus, and the inferior pulmonary ligament are divided and the oesophagus is mobilized. In doing this the opposite pleura may be opened but this is of no great importance and no attempt is made to suture the

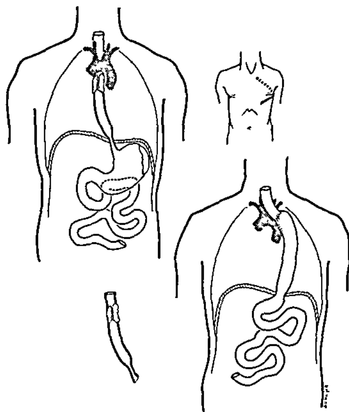


FIG. 42.—Carcinoma of the mid-oesophagus Partial oesophagectomy and oesophagogastrostomy done on the left side of the aortic arch

(By courtesy of the Editor, Annals of the Royal College of Surgeons of England)

defect. After dividing the diaphragm the stomach may be gently drawn up into the chest, its blood vessels being divided serially in such a way as to preserve the left gastric and gastro-epiploic arcades. When the stomach has been adequately mobilized the gastro-oesophageal junction is divided between clamps and the stomach is closed. That part of the fundus related previously to the spleen will usually be found to form the apex of the stomach as it is drawn up into the chest and is suitable for anastomosis to the oesophagus after the lesion has been resected; the anastomosis lies below the arch of the aorta.

If the growth is situated near the middle of the thoracic segment it will not be possible safely or easily to carry out such an anastomosis below the arch of the aorta (Fig. 42). It is then necessary to dissect out the oesophagus from behind and above the arch and, having freed it and divided it below, to bring it out so that it

lies to the left of the aortic arch. In this way the section and anastomosis can be done at a much higher level Some surgeons find it difficult to carry out the whole of this operation through one rib bed and therefore resect two ribs, the lower, say the eighth, being used for the gastric mobilization, while the upper, say the fourth, is used for the anastomosis. If this plan is adopted the initial skin incision requires to be modified from a straight oblique incision to a long J-shaped one rather like that used for a thoracoplasty. The author's experience is that this manoeuvre is not necessary and sufficient access for the whole operation is available if the sixth rib is removed together with half an inch of the posterior end of the rib above or below.

Ivor Lewis operation: transabdominal mobilization of the stomach and right thoracotomy

For lesions lying towards the middle of the oesophagus it is necessary, as has been described, to mobilize the oesophagus from behind the aortic arch if the operation is done from the left side. This can be a difficult and hazardous step and is always tedious. This consideration, together with the clear realization that the oesophagus is more a right-sided than a left-sided structure in the chest, led Ivor Lewis in 1946 to propose another method of oesophagectomy. In this operation (Fig. 43) the first step is through an upper abdominal laparotomy incision to mobilize the stomach, preserving its vascular arcades. The peritoneal attachments are divided completely, the diaphragmatic hiatus is demonstrated, and the abdominal oesophagus is dissected free and followed up as far as is reasonable.

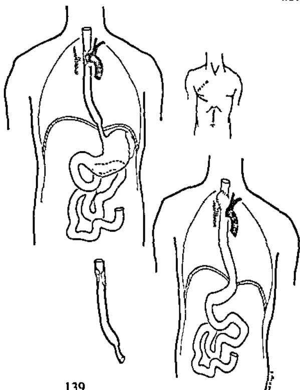


FIG 43.—The Ivor Lewis operation. Transabdominal mobilization of the stomach and partial oesophagectomy through the right pleura.

(By courtesy of the Editor, Annals of the Royal College of Surgeons of England)

While this is being done the liver and lymph nodes are inspected for evidence of metastasis. The abdomen is then closed, the patient turned on to the left side and the right chest is opened through a suitable rib, say, the sixth. After the lung has been retracted only one structure intervenes between the surgeon and the oesophagus and that is the vena azygos major. This is divided between ligatures, and the whole length of the oesophagus is then available for mobilization; when this latter step has been completed the gentlest traction will cause the stomach to slide up into the right pleural cavity through the diaphragmatic hiatus. After resection of a suitable length of oesophagus the stomach can then be used as previously described to form the new gullet. There is one difference from the left-sided operation, however, and that is that since the dissection is easy and there is no bulky structure like the aorta getting in the way, it is much easier to do the resection and anastomosis really high—the temptation to do otherwise does not exist. This is important since the commonest cause of local recurrence is the known propensity of the cancer to spread longitudinally in the submucosa and there is a temptation to skimp the resection. Any factor which makes for a higher site of resection must add to the patient's safety from the risk of local recurrence.

There is one other considerable advantage in this operation, namely, that the diaphragm is not in any way damaged. All the operations through the left chest necessitate the division of the diaphragm which, with its subsequent suture, means that it is working with diminished efficiency for some days after operation. This is important since re-expansion of the lung and proper re-aeration are largely dependent on an efficient working of the diaphragm.

It has been argued by some that the disadvantage of the Ivor Lewis operation is that the abdominal part has to be completed while the surgeon remains ignorant of the operability or resectability of the intrathoracic lesion. This is not a valid objection, since if the growth is not resectable the prime duty of the surgeon is to restore the ability to swallow and the stomach can then be used to by-pass the obstruction.

A description has been given elsewhere (Cox, 1957) of yet another method for dealing with unresectability which seems worthy of further trial. In 2 cases the growth was found to be involving the back of the right main bronchus and, in attempting to free the lesion, the oesophagus was opened leaving a plaque of disease behind. This was marked with steel clips, the operation completed in the usual way, and the patient subsequently treated by megavoltage radiotherapy. One of these patients remained alive with no sign of disease for over 3 years, the other is only about 1 year since operation.

The Ivor Lewis operation has, if one can judge by the literature, met with very little general adoption especially in the United States of America, where only one mention of it was observed in a fairly extensive but not exhaustive survey of the literature. Nevertheless, it is a good operation with several advantages and the author finds that he uses it more and more.

Operations for lesions in the upper quarter of the oesophagus

The upper quarter of the thoracic oesophagus is the part least affected by cancer and this is fortunate since a growth in this situation provides a problem which has not been properly solved either by surgeons or radiotherapists.

Operations done through the left chest have been described by both Garlock (1948) and Sweet (1948). The latter, after mobilizing the stomach and whole oesophagus through the left chest, divided the gastro-oesophageal junction and closed the stomach in the usual way. The fundus of the stomach was then anchored temporarily near the apex of the pleural cavity by a few sutures and the chest was closed. The cervical oesophagus was then exposed and in order to give better access Sweet excised the inner end of the clavicle and first rib The oesophagus could then be drawn up into the neck and after it the stomach; the resection and anastomosis were carried out in the neck.

This operation is a very severe procedure, necessitating as it does the opening of chest, abdomen (transdiaphragmatically) and neck. In order to stand a chance of success, therefore, it needs a fairly fit patient who has a sufficiently long stomach when mobilized to pass through the posterior mediastinum into the neck. These requirements are not always present and have given rise to a search for an alternative. Robertson (1954) described an operation based on a different plan, but it has the disadvantage of being a two-stage affair. At the first operation (Fig 44) a long jejunal loop is prepared using an upper abdominal incision. A tunnel is then made by blunt dissection in the anterior mediastinum keeping close behind the sternum. A cervical incision is then made and blunt dissection again makes a tunnel downwards behind the sternum; eventually the two meet and can be enlarged sufficiently to take the whole hand: the prepared loop may then be pushed—not pulled—up into the neck In the author's small experience of this operation the addition of Sweet's manoeuvre of resecting the inner end of the

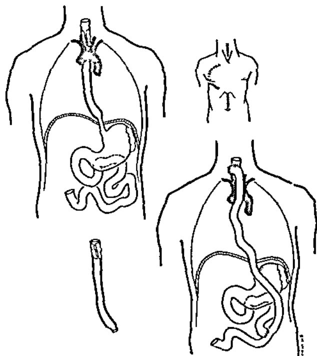


FIG 44 —Carcinoma of the upper thoracic oesophagus. Cervical oesophagojejunostomy and oesophagectomy through the right pleura.
(By courtesy of the Editor, Annals of the Royal College of Surgeons of England)

clavicle and first rib vastly increases the ease of freeing the cervical oesophagus and, having divided it, of doing the anastomosis. The lower end of the divided oesophagus is closed and allowed to slide back into the chest.

At the second stage, which is undertaken about 3 weeks later when the patient is swallowing well with his new gullet, the right chest is opened and the whole thoracic oesophagus may be removed.

Cervical oesophagojejunostomy has certain advantages over cervical oesophago-gastrostomy. The former allows of earlier restoration of swallowing and this has an immediate effect in improving the general condition and nutrition. Further, if the lesion in the oesophagus is at all advanced it may be impossible to resect through the left chest while still quite possible through the right chest. If it is quite unresectable, the first-stage operation of oesophagojejunostomy will have given the patient palliative relief, whereas oesophagogastrostomy will at this level have to be abandoned. Cervical oesophagogastrostomy being a one-stage procedure of great magnitude demands a younger fitter patient than the two-stage operation of oesophagojejunostomy, and oesophagectomy.

It will be noted from the illustration (*see* Fig. 44) that the clearance between the upper end of the lesion and the cut end of the specimen is small and this is inevitably so since any higher level of section will tend to compromise the cricopharyngeus and the larynx.

By-pass operations

Reference has already been made to the patient who has a lesion which, by virtue of extension to surrounding structures such as lung or bronchus, is unresectable, and the necessity to do something for these unfortunates which will restore to them the ability to swallow. It will be pointed out later, under the heading of radiotherapy, that such a manoeuvre is desirable as an adjunct to that form of treatment

Stomach or jejunum can be used to form the by-pass (Fig. 45) by anastomosis to the side of the oesophagus above the obstruction. Where circumstances are suitable, it would on general principles seem better to use small intestine rather than stomach for such a by-pass, since stomach is more likely to be involved by lymphatic spread at an early date with consequent likelihood of being rendered ineffective Such by-passes can be taken through the diaphragm or through an anterior mediastinal tunnel and then into one or other pleural cavity as indicated by the state of affairs found at operation (Fig. 46).

Technique

The many details of each particular operation do not need description in a survey such as this and indeed each surgeon will bring his own particular ideas and methods to bear upon the problem. There are some points, however, which the writer feels are worthy of mention.

Anaesthesia.—It would be no great exaggeration to say that it is the advances made in this technique which have contributed most to the improvements in the surgery of the oesophagus. Control of the patient's respiration and the ability to inflate the lungs was a basic necessity before transthoracic manoeuvres could be safely and easily accomplished. A further advance in this direction, in our opinion,

has been the use of a tube described by Carlens (1949), which is designed so that respiration may be carried on with one lung while the other is allowed to collapse. The tube (Fig 47) has a double lumen with 2 cuffs One lumen goes to the end of the tube which lies in the left main bronchus and is held there by the distal cuff The other lumen opens at a side eye just above a blunt hook-like projection which is intended to rest on the carina. A cuff above the side eye when inflated blocks the trachea and allows the second lumen to control the right lung. Thus, the anaesthetist can control each lung separately and one lung can be allowed to

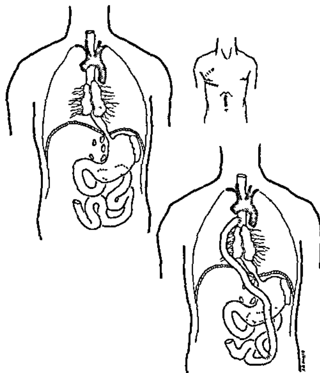


FIG. 45.—Unresectable carcinoma of oesophagus treated by by-pass operation using a jejunal Roux loop.
(By courtesy of the Editor, Annals of the Royal College of Surgeons of England)

collapse while anaesthesia and respiration are carried on through the other (Fig 48). This ability to collapse the lung on the side of operation adds greatly to the facility of approach, the absence of lung retractors allows of additional operating space and the lung itself is the better for being spared its traditional role of buffer between surgeon and anaesthetist. This device has given great satisfaction.

Operations on the oesophagus are often prolonged and productive of surgical shock. For these reasons we have in the past used hypotensive anaesthesia (Wyman, 1953), not so much for its virtues as an agent to reduce bleeding but because of the ganglion blocking effect. Some drug capable of interrupting the afferent autonomic pathway is, in our opinion, a valuable help to the patient in protecting him from shock

Management of the diaphragm.—Where the diaphragm has to be divided it is wise to do this in such a way that the line of section runs from the hiatus as far

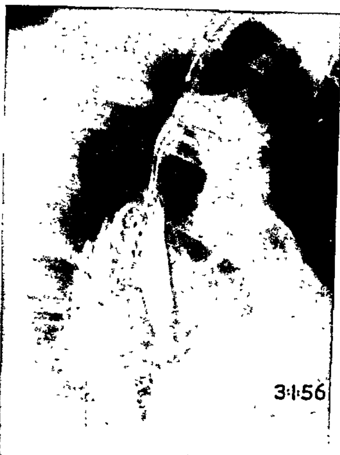


FIG. 46.—Barium swallow after by-pass operation for unresectable growth of lower oesophagus (*By courtesy of the Editor, Annals of the Royal College of Surgeons of England*)

back and peripherally as possible—not necessarily radially. If this point is observed, the maximum area of diaphragm is left in continuity with its innervation, an important point in preserving its function on which the re-expansion of the lung is in large measure dependent. On no account should the phrenic nerve deliberately be interrupted.

Methods of anastomosis.—Much discussion has centred in the past, and still does, around the question of whether the anastomosis should be done with absorbable or non-absorbable material and whether the suture should be continuous or interrupted The author has for some years now followed Allison's teaching and used one layer of chromicized catgut as a continuous suture through all coats of both oesophagus and stomach or gut Not only does this make the performance of the anastomosis quicker and neater, but he is convinced it is as safe as any other method.

Marking of unresectable growths.—In view of the increasing help which may be expected from radiotherapy in the management of unresectable growths it is important that the extent of these lesions be marked by radio-opaque foreign bodies such as Michel clips or steel wire sutures Several such markers placed so as to indicate the boundaries and extent of the disease are of great help to the radiotherapist in accurate beam direction, and the placing of them takes the surgeon only a few moments.

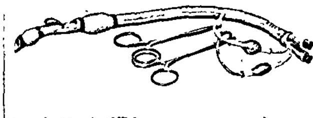


Fig 47.—Carlens' tube.
(By courtesy of the Editor, Annals of the Royal College of Surgeons of England)

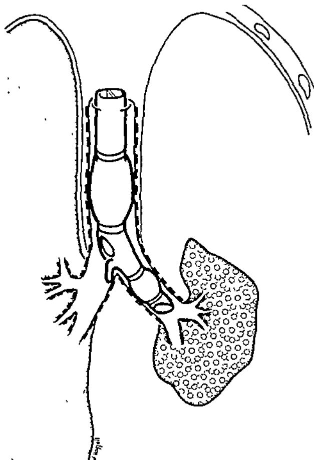


Fig 48—Diagram to illustrate method of using the Carlens' tube.
(By courtesy of the Editor, Annals of the Royal College of Surgeons of England)

Pleural drainage.—The pleura should always be drained after these operations and for several years it has been my routine to use two drains, one apical and one basal. Without the use of an apical drain it is difficult to ensure complete apposition of visceral and parietal pleura. I believe this to be important since if a leak should take place and be of only a slight degree it may be contained or form only a small local abscess if the pleurae are in contact. If, however, there is air in the pleural sac a large empyema is inevitable. A large leak is disastrous; it will almost certainly have a fatal outcome.

If it is known or suspected that the lung itself has been wounded it is even more important to make arrangements for the easy escape of air from the pleural cavity, and this is most efficiently done by using an apical drain attached to an underwater seal

RADIOTHERAPY

Up till quite recent years the part played by radiotherapy in the treatment of cancer of the oesophagus has been neither large nor impressive. At best such treatment has been palliative though a few long-term survivals are reported here and there This picture was due to the fact that but two methods were available, namely, conventional 250 kilovolt x-rays and gamma radiation produced from small quantities of radium applied as intralumenal sources.

In the last 5 years more powerful sources of x-radiation and gamma radiation have become available. These include such machines as the Van de Graaff generator (2 million electron volt x-rays), the Linear Accelerator (4 million electron volt x-rays) and the Theratron (2,000 curie telecobalt unit). The employment of such megavoltage radiotherapy apparatus will undoubtedly have a beneficial effect on the results of the treatment of cancer in such a deep-seated organ as the oesophagus, but it is too early as yet for any large amount of clinical experience in their use to have accumulated. Nevertheless, certain hopeful trends are becoming apparent.

It must be clearly appreciated in assessing the place of radiotherapy that certain unfavourable factors apply to any method which may be used. First, there is nearly always some degree of selection at work so that only the "worse" cases are sent for radiotherapy: the cases may be "worse" in the sense that the patients are of very poor general health and physique or have advanced local disease or even disseminated malignancy Secondly, there is the problem of fibrosis. It is implicit in any method of radiotherapy that both healthy and malignant tissues are subjected to radiation, that tissue damage of some extent will thus be caused, and in the process of repair and recovery fibrosis will occur. The degree and severity of this fibrosis, like any biological response, will vary from patient to patient and cannot be predicted with any certainty. In the case of carcinoma of the oesophagus, stenosis is already present, there is often considerable infection, and the factors at work tending to dilate the oesophagus are weak. It is not surprising, therefore, that after an initial period of amelioration the symptoms of stenosis return and may be more severe than before. Furthermore, the dysphagia which in the first instance was painless may, if the radiotherapy has been severe, now be painful. Thirdly, many of the cases sent for radiotherapy will not have been explored surgically and the radiotherapist is therefore uncertain as to the

extent of the disease which he is trying to treat. It is never easy, and sometimes impossible, to be certain where lies the lowest limit of cancer in the gullet and distant lymphatic, and visceral spread may already have occurred without giving any clue.

Nevertheless, radiotherapy has much to offer, especially if a good food passage can be ensured. This can certainly be done if surgical excision or by-pass operation precedes the radiotherapy The writer feels that this is a better plan than that advocated by Mustard (1957) in which the irradiation comes first and is followed later, if indicated, by some form of by-pass operation. Surgery should come first because: (1) the growth may unexpectedly be easier to resect than was anticipated; (2) if not resectable, the maximum information about its extent and spread may be obtained and the confines may be marked to aid beam direction; (3) if left till after radiotherapy the patient's condition may have further deteriorated to such an extent as to make operation increasingly dangerous; and (4) the tissues after full irradiation do not react kindly to surgery and healing is delayed and less vigorous.

The indications for radiotherapy may therefore be summarized as follows: (1) unresectability of the tumour; (2) residual disease left after a palliative resection and anastomosis; (3) evidence of distant spread of the disease, such as supraclavicular lymph node or hepatic enlargement, especially if the primary is unfavourably situated in the upper oesophagus; (4) cardiac or pulmonary disease of such severity as to contra-indicate surgical attack; and (5) local recurrence after previous operation for resection.

As megavoltage apparatus becomes more widely available, consideration will have to be given to the question whether patients should not receive routine post-operative radiotherapy to the posterior mediastinum just as patients with carcinoma of the breast are given post-operative radiotherapy following radical mastectomy. Only experience and the clinical experiment is likely to give the answer to this problem.

It would seem useful briefly to review the various methods of providing radiotherapy.

Conventional x-rays, 250 or 400 kilovolts

For many years this has been the standard method available for the radiotherapist, but the results even as judged by short-lived palliation have not been good This is due chiefly to the difficulty of delivering a sufficient depth dose. It is generally agreed that to "cure" a squamous-cell carcinoma it is necessary to give at least 6,000 roentgens With 250 kilovolt x-rays it is difficult to deliver more than 4,500 roentgens to the oesophagus and even this dose produces quite considerable skin and general constitutional disturbance However, when there is absolutely no other alternative available, this form of therapy is worth trying as every now and then sensitive cases are found which respond and provide a pleasant surprise.

Intralumenal radioactive sources

The French laryngologist Guisez (1925) first described this method which is capable of producing remarkably good palliation. In order to apply this method

it is necessary to be able to dilate the malignant stricture so that a radium loaded tube can be passed through it. Generally a 1-centimetre diameter stomach tube is used and it is loaded with 4–6 containers each of 10 milligrams of radium. Radioactive cobalt also emits gamma rays and serves equally well. The stomach tube is introduced so that the segment containing the radioactive sources lies within the malignant stricture and overlaps it by at least 1·5 centimetres at either end. The tube is kept in place for 24 hours and it is surprising how well the patients tolerate it if properly sedated. At the end of 12 hours it is important to move the tube either up or down a distance equivalent to half the length of one of the radium containers. This is done in order to provide for even dose distribution of the radiation. A treatment of this kind is repeated at weekly intervals, and at the end of 3 weeks will result in a dose of 9,000r at the surface and 5,100r at a depth of 1 centimetre.

The advantages of this treatment are that it is quick, taking only 3 or 4 weeks as against 6–8 weeks for external radiation, it is well tolerated even by aged and frail patients, and owing to the mechanical dilatation reinforcing the effects of the radiation the immediate result is always good The disadvantage is that as the depth dose falls off rapidly any but the most superficial lesions is unlikely to receive a curative dose and therefore recurrence after an interval is all too common.

Van de Graaff x-ray generator (2 million electron volts)

This apparatus produces x-rays of such high energy that they closely resemble gamma rays in their biological effect, in addition the focal skin distance is very long, being 100 centimetres, and therefore provides a high percentage depth dose. This means that it is an easy matter to deliver 6,000r to the oesophagus without disturbing the patient in any way and leaving his skin unmarked.

Using this machine, regression of squamous-cell carcinoma may confidently be expected, but those in charge of the patient must be alert to note the first return of dysphagia. This may denote the onset of fibrous stenosis which is always more advanced and severe than the symptoms would lead one to expect and may call for repeated oesophagoscopic dilatation with bougies.

Another warning which is necessary is not to treat by this or any other form of radiotherapy those growths which lie between the oesophagus and bronchus. If the lesion is sensitive and responds, the result may well be a broncho-oesophageal fistula with all the misery which that entails.

Theratron (2,000 curie telecobalt unit)

A beam of gamma radiation which in certain respects is comparable to the Van de Graaff generator is produced by this apparatus. The Theratron is so designed that it is capable of rotating completely round the patient, instead of delivering its dose through several fixed ports of entry as in the case of x-ray machines. This rotational therapy has the advantage that it reduces to the minimum the risk of unpleasant and undesirable side effects, such as lung fibrosis, due to a fixed beam traversing normal tissues.

Linear Accelerator (4 million electron volts)

The Linear Accelerator is of fairly recent introduction and may still be said to be in the stage of clinical research. With such very high energy radiation the

treatment times are very short, the undesirable biological effects such as fibrosis are reduced to a minimum and there is some reason to believe that adenocarcinoma may be sensitive, at any rate in a proportion of cases. Much work still remains to be done in assessing the potentialities of this apparatus.

RESULTS

These have been collected for the author's series from 1948–57 Out of a total of 102 cases 10 per cent at exploration were found to be unresectable while another 15 per cent were found to be unfit for any form of major surgery. The operative mortality for major resections was 38 per cent which agrees fairly closely with figures from other sources (Klein and Garlock, 1956, Mustard, 1956; MacManus and Paine, 1956)

There are in the literature various figures which seem to show that the prognosis for adenocarcinoma involving the oesophagus is as good as for squamous-cell carcinoma (Sweet, 1952; Mustard, 1956), but the writer's experience does not support this view Indeed, it would be surprising if adenocarcinoma, which is after all stomach cancer and notoriously malignant, were to have the same

TABLE II

CAUSES OF DEATH IN HOSPITAL

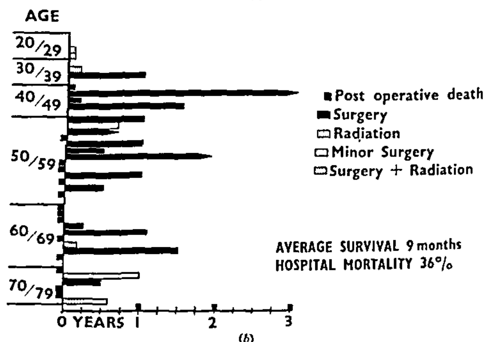
Bronchopneumonia	10
Anastomotic leak	5
Perforation of oesophagus	4
Post-operative shock	4
Progress of disease	3
Myocardial failure	2
Renal failure	2
Hepatic necrosis	1
Massive necrosis of stomach	1
Empyema	1
Total	33

prognosis. The outlook is bad enough in either case as is shown in Fig. 49 (*a*) and (*b*) Each patient is represented by a horizontal bar, the hatching of the bar representing the method of treatment and the length of the bar the survival—those with pointed ends are still alive and those with square ends are dead. Post-operative deaths are indicated as short bars on the left of the vertical ordinate line. The patients have been arranged in groups according to their age in decades.

It will be observed that there are more cases of squamous-cell carcinoma than of adenocarcinoma, that there are more long-term survivors from squamous-cell carcinoma than from adenocarcinoma and the average survival is 19 months as against 9 months Post-operative deaths occur a decade earlier with adenocarcinoma and this is also the case with both the initial incidence and peak incidence of the disease. The post-operative and hospital mortality are both higher for adenocarcinoma than squamous-cell carcinoma.

AGE
30/39
40/49
50/59
60/69
70/79
80 +
■ Post operative death
■ Surgery
▭ Radiation
▭ Minor Surgery
▭ Surgery + Radiation
AVERAGE SURVIVAL 15 months
HOSPITAL MORTALITY 26%
0 YEARS 1 2 3 4 5

(a)



(b)

Fig. 49.—Age and survival of patients with (a) squamous-cell carcinoma and (b) adenocarcinoma.

(By courtesy of the Editor, Annals of the Royal College of Surgeons of England)

Table II shows the causes of death of patients dying in hospital. Far and away the commonest cause is bronchopneumonia and this indicates one of the lines along which further improvement must be sought. Of the 5 cases dying with anastomotic leaks 4 suffered from adenocarcinoma, yet a further confirmation, if such were required, that stomach cancer is a most serious and deadly disease. It has a sinister ability to undermine the patient's powers of recovery.

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PROGRESS IN PULMONARY SURGERY

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INTRODUCTION

In this review we propose to consider the three common infective intrathoracic conditions of lung abscess, empyema and bronchiectasis. In each case considerable changes have occurred during the past decade not only in the incidence and clinical manifestations of the disease but also in the management of the condition and the results of treatment. That most of this change has been due to the introduction of antibiotics there can be little doubt; antibiotics given in the early stages of an acute respiratory infection prevent the development of serious complications such as an abscess or an empyema whilst used later for established complications they have, in many cases, resulted in cure or at least produced considerable amelioration of symptoms. In addition, antibiotics used in conjunction with surgery have not only made the standard thoracic operations safer but have enabled more enterprising and radical procedures to be carried out.

Although we are only considering the three commonest suppurative lesions many of our remarks apply equally well to other infective lesions.

PULMONARY SUPPURATION

The more serious infections of the lung leading to suppuration and necrosis are most frequently due to the inhalation of infected particulate matter. Common predisposing conditions are dental and oral sepsis, upper respiratory infections and chronic bronchitis whilst precipitating factors include operations, injuries and coma.

The initial change in the lung is a simple segmental atelectasis on to which inflammatory changes are grafted. Subsequent events depend largely on the relative degree of suppuration or necrosis or both occurring in the inflamed segment: this, in turn, is influenced by the nature of inhaled material and the organisms which it contains, the state of the blood supply of the affected segment and the general condition of the patient. At one end of the scale a subacute infection with suppuration but little necrosis develops, whilst at the other end one finds the acute putrid abscess associated with considerable necrosis and destruction of lung tissue.

Before the advent of chemotherapy, severe varieties of pulmonary suppuration were frequent, their management was difficult and the outcome of the disease uncertain. Medical and conservative measures of treatment were meeting with little success, whilst surgery, though giving rather better results, still left much to be desired. The surgical treatment of choice at that time was external drainage which carried a mortality of between 25 and 30 per cent, and approximately two-thirds of the survivors were cured. This represented a definite advance on the best available medical means at that time but still left considerable room for improvement.

However, with the advent of chemotherapy and the multiplication of antibiotic agents, the whole scene changed. This has been brought about in four ways.

(1) The use of antibiotics at an early stage in the disease has largely prevented the development of the more severe types of infection. As a result, the acute putrid lung abscess is much less common, although conversely, the more chronic forms of pulmonary suppuration have increased.

(2) In the management of established cases, adequate chemotherapy has resulted in complete resolution in approximately 75 per cent.

(3) Those patients who are not cured by chemotherapy are rendered fit enough to withstand a formal deliberate resection of the affected parts.

(4) The incidence of metastatic complications such as cerebral abscess, empyema and pericarditis has fallen considerably.

Antibiotics, however, have produced certain complications of their own. The resident bacterial flora in a hospital now contain a considerable number of pathogens which are resistant to some, or many, of the usual antibiotics so that, should infection by one of these organisms occur, chemotherapeutic treatment is difficult. In addition, the frequent exhibition of antibiotics prophylactically to patients in hospital, particularly as an operative cover, has resulted in the emergence of resistant strains in the patient's own bacterial flora. These two factors have resulted in the development of a number of serious pulmonary infections involving resistant organisms and occurring as a complication of surgery or in association with an independent medical condition.

Clinical features

The classical story of an acute lung abscess with an influenzal-like febrile onset followed in a week or 10 days by the sudden expectoration of considerable quantities of foul sputum is rarely elicited today. The whole tempo of the illness is retarded by chemotherapy. The original illness is often diagnosed as pneumonia and treated forthwith by antibiotics so that the usual maturation of the abscess is modified Should the appropriate drugs be continued, complete resolution may occur, but too often they are stopped too soon and subacute or chronic infection remains; the symptoms are thus somewhat vague and indefinite. Fever is usual but not pronounced Pain in the chest of pleural type is frequent, and coughing is variable The sputum is not usually copious or foul but is unquestionably purulent and may be blood-stained The foetid breath so characteristic of the acute lung abscess is rarely detected but finger clubbing may occur at any early stage and advance rapidly.

This rather chronic indefinite type of illness is much more reminiscent of a carcinoma than of an abscess and it is perhaps significant that many patients found to be suffering from pulmonary suppuration have been regarded initially as having cancer. Cancer has become one of the most important conditions in the differential diagnosis.

Investigations

Radiology

X-rays are invaluable for the diagnosis: initially they reveal an area of consolidation of segmental distribution and shape. It is essential for the diagnosis to take films in both the lateral and the antero-posterior planes, for only in this way can the segmental type of lesion be distinguished from others. An actual cavity or a bubble of air may be visible but is not indispensable for the diagnosis.

Examination of sputum

At an early stage it is essential to carry out complete bacteriological examination of the sputum including the sensitivity to antibiotics of any organisms present Tubercle bacilli and malignant cells should be sought at the same time.

Bronchoscopy

This is an essential part of the investigation. It is not designed to localize the abscess or to be used therapeutically but must be carried out in order to exclude the presence of an underlying carcinoma, foreign body or stricture. At bronchoscopy, it is often possible to detect the typical foetid odour of the abscess which was not detected in the breath.

Bronchography

This investigation is being used more widely in problems of this type. It can be of value in distinguishing between an abscess and a segmental carcinoma where the relevant bronchus is not visible at bronchoscopy. It is also advisable to obtain full bronchographic delineation of the bronchial tree prior to carrying out a formal resection. Only in this way can one be certain that all diseased and damaged lung is removed at the time of resection.

Management

The first task in the management of a lung abscess has already been outlined, namely the confirmation of the diagnosis, the exclusion of an underlying lesion and the determination of the causative organisms. With this information available, a campaign of vigorous physiotherapy combined with long-term chemotherapy is instituted.

Physiotherapy

The essential aim of physiotherapy is the provision of adequate drainage. This is achieved by posture; the patient is placed in such a position that the infected area of the lung lies above the draining bronchus. Postural drainage is usually combined with percussion with the flat of the hand over the site of the abscess: in this way, pus and debris are often extruded from the abscess into the bronchus whence they can be expectorated Postural drainage and percussion therapy are

combined with breathing exercises which, of themselves, tend to encourage better drainage and prevent the development of a contracted, poorly moving chest. Postural drainage, to be effective, should be carried out for long periods at a time, ideally between half and one hour several times a day, although those who are very ill may not tolerate such prolonged periods.

Chemotherapy

The essential factors here are the selection of suitable antibiotics, their administration in large doses and in combinations of two or more (to help to avoid resistance) and their exhibition for a long period. Wherever possible, penicillin or streptomycin should be used initially and the wider spectrum antibiotics, such as tetracycline, chloramphenicol and so forth should be reserved for those patients in whom penicillin is inappropriate.

Resolution of the abscess may take many weeks and treatment along the above lines should be continued whilst there is still evidence of improvement either clinically or radiologically. A minimum period of 6 weeks is usually necessary and often 2–3 months' treatment is required for complete resolution.

With the above regime, 75 per cent of suppurative lesions resolve satisfactorily. These patients become free from cough and sputum and straight radiographs show clearing of the consolidated area of the lung. Bronchograms, however, at this stage usually reveal damaged, dilated bronchi but these may never give rise to further trouble.

Open drainage

This procedure, once the surgical method of choice, is only rarely required for those patients not responding to chemotherapy who are considered to be unfit or unsuitable for resection It is an operation which is infrequently performed.

Lung resection

Formal resection of lung by lobectomy, or occasionally pneumonectomy, has largely replaced open drainage as the operation of choice. It is required when symptoms or radiological changes persist after a prolonged period of conservative treatment. Even if chemotherapy does not cure the lesion it usually results in such an improvement in the local condition as well as in the general condition of the patient that thoracotomy becomes a relatively safe procedure. At thoracotomy it is important to remember that the involved tissues may still be highly infected and that resection should be carried out through normal, or relatively normal, planes. The more conservative type of segmental resection so admirable for treating chronic tuberculous lesions has little place in the treatment of this condition. It is always wiser and safer to remove the whole involved lobe rather than try to conserve one or more segments at the risk of spreading infection to other parts

In the post-operative management it is even more important to ensure that the lung tissue that remains behind expands rapidly to fill the pleural cavity, thus minimizing the chances of an empyema or broncho-pleural fistula.

The results of surgical resection are very gratifying with low mortality and morbidity.

Prognosis

The use of long-term chemotherapy and surgical resection has resulted in a very much more favourable outlook for patients with pulmonary suppuration. Not only are 75 per cent cured by chemotherapy but the remainder have an equally good chance of cure even though at the expense of losing a portion of their lung. From being a particularly lethal and malignant disease, lung abscess has now lost many of its former terrors.

EMPYEMA

The incidence and course of acute thoracic empyemas have radically altered during recent years. The disease is much less common and more benign than it was. Empyema drainage formerly the most commonly practised operation in thoracic surgery is now seldom performed. Acute empyemas with marked toxic manifestations are uncommon although the relative incidence of the more insidious and chronic types has probably increased. There can be little doubt that these changing characteristics are largely due to the impact of antibiotics.

The change in the characteristics of the disease has, however, produced its problems No longer are there urgent manifestations demanding the intelligent use of the exploring needle and too often, today, one finds this valuable diagnostic weapon has been entirely neglected or perhaps replaced by other more elaborate methods of investigation such as bronchoscopy, bronchography and tomography. These latter methods are admirable for the determination of the cause of an empyema but help little in its diagnosis.

Aetiology

Pneumonia, once the commonest cause of an empyema, has become an uncommon aetiological factor. The classical pneumococcal empyema with copious pus and large fibrin masses is rarely seen, antibiotics, to which the pneumococcus remains particularly sensitive, have largely prevented the occurrence of this complication.

As a result, a higher percentage of empyemas are now found to be due to other, more sinister, pulmonary conditions of which carcinoma deserves very special mention Bronchiectasis, subphrenic abscess and lung abscess are occasionally implicated This implies that the majority of patients with empyema now require full pulmonary investigation to determine the exact aetiology. This should be carried out at an early stage as the nature of the underlying pulmonary disease will obviously affect the method of treatment

Diagnosis

The diagnosis can be made only by finding pus with the exploring needle—there is no other way—but too often exploration fails to reveal pus which is very obviously present Such failure may be due to a blocked needle, a leaking syringe or to masses of fibrin occluding the needle, but usually it is because the needle has been introduced at the wrong site It is essential to localize the collection of fluid carefully on postero-anterior and lateral radiographs using fluid levels, if they are present, as a guide. The optimal site, as determined radiologically, is then noted on the patient and confirmation obtained by eliciting the appropriate physical signs.

A 20-millilitre syringe with a close fitting barrel is the most convenient size for use in exploration and a No 18 S.W G needle 2½ inches long is firmly attached either directly to the syringe or through a 3-way tap. Flexible rubber connexions are undesirable for exploration—needle, tap and syringe should be in one solid leakproof piece.

When fluid is encountered two specimens should be removed, one of which is retained in the ward for comparison with subsequent specimens and the other is used for bacteriological and cytological examination. As much fluid as possible should then be removed using the 3-way tap to prevent the entry of air into the chest. Finally 20 millilitres of iodized oil and 1 million units of penicillin are injected. The former will indicate the lower limits of the empyema on subsequent radiographs whilst penicillin is advisable until the bacteriology is known.

Investigation

It has already been said that empyemas secondary to simple pneumonic lesions have become relatively rare so that a greater proportion of patients have underlying pathological conditions of the lung of a chronic (bronchiectasis) or serious (carcinoma) nature which require elucidation before treatment can be planned.

Symptoms such as cough, sputum or haemoptysis suggesting a pre-existing lung lesion may be present whilst the presence of clubbing strongly suggests underlying sepsis or malignancy.

Bronchoscopy and bronchography are probably essential investigations in the majority of patients and usually will provide the right answer

In all patients a careful search for tubercle bacilli in sputum and pleural pus should be undertaken.

Early management

In all patients, whatever the treatment which will finally be adopted, vigorous breathing exercises and early ambulation are very necessary if maximum function of the chest wall is to be obtained

Two main problems—the infection and the dead space—will dictate subsequent management

Management of the infection

Pus removed at the first aspiration should already have been cultured, the organisms identified and their sensitivities determined. Aspirations should there- [illegible]

introduce any air into the cavity as this will delay the expansion of the lung and obliteration of the dead space. With regular aspirations the majority of empyemas can be sterilized within a week or 10 days

Liquefying agents such as streptokinase and streptodornase (Varidase) and trypsin are valuable should the pus be unduly thick or there be much fibrin. Streptokinase and streptodornase are mixtures given in doses of 200,000 units of the former and 50,000 units of the latter at the conclusion of an aspiration. These doses, given intrapleurally, can be repeated on subsequent aspirations if the fluid remains thick. With 2 or 3 injections, however, the fluid usually becomes watery

and blood-stained and can be readily evacuated. Trypsin (Trypure) is perhaps even more effective and is given in doses of 50 milligrams and used similarly to streptokinase.

Management of the dead space

An empyema can only be regarded as cured when the pleural space has been obliterated by the expansion of the lung and its fusion to the chest wall The following methods can be used to achieve this end.

Repeated aspirations

In many instances regular aspirations will result in the full expansion of the lung and obliteration of the pleural cavity provided the visceral pleura is not unduly thickened; this is particularly so in children, and drainage or decortication is rarely required in these patients. One should never be satisfied with a solitary dry aspiration and subsequent attempts should be made at intervals in order to make sure that fluid has not reaccumulated; radiological control is necessary throughout and the final picture should show only slight pleural thickening.

Drainage

Drainage of an empyema is required only for those patients in whom aspiration and chemotherapy fail to control the infection or where a residual dead space is present in patients who are unfit for the more major procedure of excision of the empyema. It is advisable to resect a small portion of rib towards the lower limit of the empyema cavity, evacuate its contents, remove all fibrin masses and insert a wide-bore tube. A portion of pleura should also be removed for histological examination. Initially, the drainage tube should be connected to an underwater seal bottle but, as soon as possible, open drainage combined with full ambulation should be obtained. The gradual shrinkage of the empyema is observed with serial pleurograms obtained by filling the empyema cavity with iodized oil prior to radiography. The tube should only be removed when there is no longer a space present.

Excision of empyema

This is considered by many to be the operation of choice for the empyema which cannot be controlled by aspiration. The operation is a major one and is not suitable for those who are frail or ill or have any underlying lung disease. A bronchogram is advisable before operation in order to ensure that the lung is healthy and capable of expansion after pleurectomy. The advantages of the operation are that the empyema is removed together with the thickened parietal and visceral pleura leaving the lung free to expand fully and completely to fill the residual space. The success of the operation depends on obtaining the immediate full re-expansion of the lung. In successful cases the patient is convalescent in 10–14 days and does not require tube dressings or other skilled nursing. Return to work is much earlier and the functional results are better than with drainage The operation consists of performing a wide thoracotomy over the site of the empyema. The parietal wall of the empyema is stripped by forcible blunt dissection from the chest wall and the dissection continued until the whole empyema and the lung are mobilized; when this is completed, the dissection is carried on between the inner wall of the empyema and the lung. In many instances the empyema can be removed intact although frequently the diaphragmatic attachments are so dense as to make

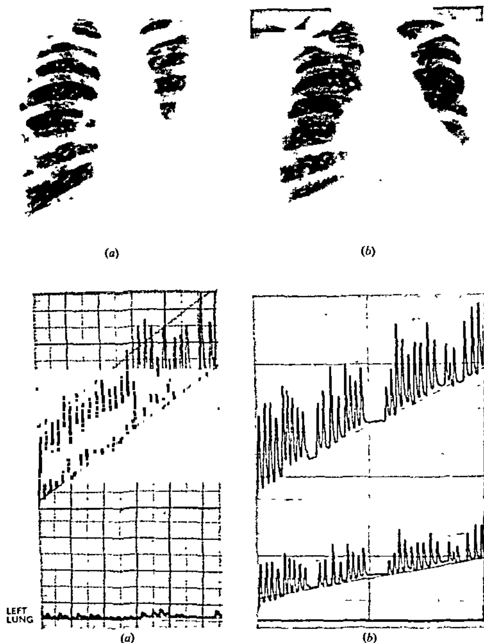


Fig. 50.—Skiagrams and bronchospirometric tracings (a) before decortication of left lung, M B C. 63 l./min.; (b) 21 months after decortication, M B C 94 l./min. (Time in seconds.) (*By courtesy of Dr. T. Savage and Dr H A. Fleming and the Editor, Thorax*)

intact removal difficult. After the lung has been decorticated, any residual puckering or adhesions in the pulmonary fissure are broken down. The pleural space is drained, usually with two tubes, and suction applied to these and maintained until there is no further escape of air or fluid and the lung fully expanded. Early ambulation and vigorous physiotherapy are an essential part of the treatment

The chief advantages of pleurectomy are as follows: (1) Rapid elimination of the infected pocket and the dead space; (2) a rapid convalescence; (3) the avoidance of long-term drainage tubes requiring special nursing attention; (4) improved functional results obtained by the removal of the thickened pleura.

Pleurectomy combined with lung resection

If the preliminary investigations which have already been outlined indicate the presence of underlying chronic lung disease, the latter should be removed at the time of the thoracotomy. The procedure is carried out as for a simple pleurectomy with full mobilization of the empyema as a first step. When complete the affected lung can be resected readily.

It may be necessary to reduce the size of the residual pleural space in some patients in whom a lobe has been removed if it is considered that the remaining lobe is incapable of filling the space. A small upper thoracoplasty with removal of a portion of the upper 3 ribs is the most satisfactory method of dealing with this problem. Care must be taken, however, not to remove too much rib for fear of producing undue paradoxical movement of the chest wall.

Results of surgical treatment

Lung function after pleurectomy

One of the main attractions of the operation of pleurectomy is the improvement in lung function which follows successful operation (Fig 50) Clinically, improved ventilation is obvious with better chest wall movement and air entry whilst radiologically the decorticated lung can be seen to ventilate satisfactorily. Savage and Fleming (1955) using bronchospirometric studies at intervals after operation, have shown that the oxygen uptake of the lung also improves after operation although this improvement is delayed more than the ventilatory function.

There can be little doubt that pleurectomy not only offers a more rapid convalescence than other forms of surgical treatment but the ultimate functional result would also appear to be considerably better.

BRONCHIECTASIS

There has been little radical change over the past 10 years in the general management of patients with bronchiectasis but the indications for surgical treatment and the recognition of those patients who are unsuitable for surgery have become clearer. The incidence of the disease is almost certainly waning and this is largely due to the improved management of respiratory illnesses in childhood.

Aetiology

Bronchiectasis can be defined as a dilatation of the walls of medium-sized bronchi accompanied by chronic infection.

Some degree of bronchial dilatation occurs in many lung diseases, notably in lung abscess, in pulmonary tuberculosis and in areas of chronic pneumonitis. In these cases the dilatation is of small peripherally situated bronchi but in true bronchiectasis the dilatation is of larger bronchi, nearer the hilum of the lung, and it has arisen primarily as a result of bronchial obstruction rather than infection.

Bronchial obstruction leads to atelectasis, and the bronchi of an atelectatic lobe become dilated owing to their distension with secretions. This dilatation is reversible provided that infection does not occur; the bronchi will return to a normal calibre when the obstruction is relieved. When infection occurs, however, permanent damage is produced and bronchiectasis is established.

Pathology

In children, bronchial obstruction which leads to bronchiectasis is most often caused by enlarged intrapulmonary and hilar lymph nodes developing in an attack of measles or whooping-cough The bronchi are obstructed by pressure from without. In a minority of cases the enlarged lymph nodes of a primary tuberculous complex will produce bronchial obstruction leading to bronchiectasis. In adults, inhaled and retained foreign bodies (Linton, 1957) frequently lead to bronchiectasis

Medium-sized bronchi are affected and they become dilated in cylindrical fashion or become sacculated. It has now been recognized that the cylindrical type of dilatation may still be reversible and that it indicates relatively minor damage to the bronchial walls; if good drainage from the lobe can be established the bronchi may return to normal

Saccular bronchiectasis results from extreme distension of a bronchus by secretions distal to a block. Later, infection occurs and the mucosa of the dilated bronchi loses its ciliated epithelium and is replaced by a more flattened epithelium or by cuboidal cells. There is fragmentation and loss of elastic tissue in the wall of the bronchus and small submucous abscesses are common In the lung distally a variety of changes is seen, depending on the length and severity of the coexisting chronic pulmonary infection At one extreme is a solid lung containing a mass of dilated bronchi; there is complete atelectasis with extensive fibrosis and the alveoli are unrecognizable; at the other end of the scale there are patchy areas of fibrosis with interspersed zones of emphysema but there is little or no shrinkage of the involved lung There is frequently a striking lack of carbon pigment in the bronchiectatic lung, and another common feature, particularly in cases which have originated as a result of pulmonary tuberculosis, is the small diameter of the pulmonary arteries compared with normal, whilst the bronchial arteries are often hypertrophied (Gobbel and his colleagues, 1951). These large bronchial vessels can give rise to considerable technical difficulties at operation.

Bacteriology

In bronchiectasis the [illegible]
but in the very " [illegible]
and spirochaetes [illegible]
lung the organism most commonly isolated is again *H. influenzae* but pneumococci and Friedlander's bacillus are frequently found.

Distribution

In about a third of all cases bronchiectasis is bilateral and affects lower much more commonly than upper lobes as it is a disease essentially of lung which is dependent. Upper lobe bronchiectasis most commonly arises as a result of lymph node obstruction from pulmonary tuberculosis. Isolated bronchiectasis affecting one segment only is not uncommon, the lingula being an example. The left lower lobe is involved more often than any other part of the lung.

Clinical features

Certain groups of patients can be recognized as follows:

Symptomless

In a few patients the bronchiectasis is discovered accidentally. The affected part of the lung remains uninfected and causes no symptoms whatsoever.

Recurrent bronchitis

This is the commonest clinical presentation of the disease. The patients are subject to mild recurrent pulmonary infections and between these attacks have still a persistent cough, but this is productive of only a small amount of purulent sputum, amounting to no more than 1 ounce in the day. The attacks occur more frequently in the winter and are often initiated by a cold which rapidly descends to the chest. The lung involved in the superadded infection is the bronchiectatic area but the physical signs are not necessarily localized to it, and there may be radiological shadowing indicating pneumonitis in lung which is considered to be normal Furthermore, if bronchoscopy is performed during such an attack generalized swelling and reddening of the bronchial mucosa may be seen. Such patients are considered to have chronic bronchitis besides the bronchiectasis and in many cases there is also a history of "asthma", as they have a wheezing chest, particularly during an exacerbation of infection An allergic history is obtainable in a few patients. Selection for surgical treatment from this group is often a matter of great difficulty and judgment.

Recurrent haemoptysis

This is the chief symptom in another group of patients. The amount of blood coughed up is seldom large but the attacks may last for several days. Between attacks the patient may be entirely symptom-free or may have only a slight cough with mucoid sputum. The attacks are usually due to a mild superadded bronchial infection in the affected lobe but often bleeding occurs for no apparent reason.

Purulent bronchiectasis

This group presents the classical form of the disease, with chronic cough productive of much purulent sputum, up to 20 ounces a day, and these patients are liable to severe exacerbations of infection; usually, though, the infection remains fairly well localized to the diseased area. A considerable volume of lung is affected by the disease, either a whole lung or both lower lobes together with the middle lobe or lingula. Finger clubbing is common and cerebral abscess, a recognized but now extremely rare complication, is also found in this type of patient.



FIG 51. — Left lateral bronchogram showing *crowding and dilatation* of bronchi of left lower lobe.



FIG. 52 — Left lateral bronchogram, same patient as in Fig 51, 9 months later, showing a normal bronchial tree

Reversible bronchiectasis

Some children with a past history of measles or whooping-cough may present with cough, purulent sputum and a liability to superadded pulmonary infections. Bronchography may outline bronchiectasis of several lower lobe segments but the dilatation is cylindrical and the lobe is normally expanded. Spontaneous improvement in the clinical and radiological picture amounting to a complete return to normal can sometimes occur. Figs. 51 and 52 are bronchograms illustrating reversible bronchiectasis and underline the importance of deferring decisions as regards the need for surgery in children.

Bronchography

Complete bilateral bronchography is essential in the assessment of any patient with bronchiectasis. Incomplete bronchograms or films with poor contrast may be misleading and no effort should be spared to obtain good pictures. There have been no major developments in the technique of bronchography in the past 10 years apart from the introduction and now widespread use of a water soluble ester of di-iodo pyridone (Dionosil). The advantage of this material over Lipiodol is that it is rapidly absorbed from the bronchial tree, usually all traces of it have disappeared from the chest radiograph within 48 hours, so that interpretation of subsequent films is uncomplicated by residual opacities.

For a surgical assessment only one side at a time should be examined and it should again be emphasized that every bronchus must be clearly outlined. Particular care should be taken to get good filling and a clear picture of the lower apical segments and of the lingula.

Further assessment

Bronchoscopy should be performed, especially in adults, in order to make quite certain that the bronchiectasis is not secondary to a retained foreign body or to a tumour. In bilateral disease the examination can be helpful in determining the amount and type of secretion coming from each side and this may be a guide in selecting the side of the first operation if surgery is planned. Repeated bronchoscopy with aspiration of secretions is probably of little value in the management of bronchiectasis.

Lung function tests are not usually necessary except in those patients with bilateral disease where extensive resections are envisaged.

The patient's response to a course of breathing exercises and regular postural drainage must be carefully assessed before coming to a decision as regards surgical treatment.

Associated paranasal infection

Thirty per cent of children and adults with bronchiectasis have associated paranasal sinus infection (Riggins, 1941), and the presence of such an infection has considerable bearing on prognosis for it is difficult to cure either disease when they coexist. It is generally considered that the sinusitis is secondary to the bronchiectasis as in most cases there is a clear history of the chest symptoms antedating the nasal symptoms. Radical surgery on the paranasal sinuses usually fails in its object if bronchiectasis coexists and such surgery should be postponed until after the lung infection has itself been treated surgically, or brought and kept under control by medical treatment

Course of the disease

The natural history of untreated bronchiectasis is a story of gradually diminishing lung function as recurrent respiratory infections take their toll on the lung. Spread of bronchiectasis so that new areas of bronchial dilatation occur is, however, a rare occurrence but "spill-over" infections resulting in areas of pneumonitis in parts of the lung on either side remote from the main bronchiectatic area heal by fibrosis and result in a lowering of the respiratory reserve. As age advances shortness of breath as a symptom is added to those already existing and ultimately death occurs during a pneumonic episode which may be associated with right heart failure. Some patients develop a chronic cor pulmonale and this may become the dominant feature of their condition.

Medical treatment

Physiotherapy

Breathing exercises are taught and postural drainage carried out at least twice daily. Tipping frames need not be employed, simple elevation of the patient's bed on 18-inch blocks is adequate.

Antispasmodic drugs

In patients with any associated bronchospasm a bronchodilator such as choline theophyllinate (200 milligrams, three times a day by mouth, for an adult) should be given. Alternatively a mist inhaler containing Isoprenaline may be used.

Antibiotics

These now play a very important role in the medical management of the bronchiectatic patient The sputum should be cultured, preferably from a specimen taken as a bronchial swab at bronchoscopy, and the exact nature and sensitivity of the infecting organism determined. As already stated *H. influenzae* is usually found in pure culture and this organism is at present adequately sensitive to wide spectrum antibiotics; furthermore, it has little tendency to develop resistant strains. A course of a suitable antibiotic can be given at the outset of medical treatment and this will greatly reduce the number and virulence of the organisms in the sputum, but in the case of *H. influenzae* it is not possible to eradicate the organism altogether. In patients with very wet bronchiectasis, and in those who have a tendency to frequent attacks in winter of acute respiratory infection, a maintenance dose of an oral antibiotic can be given. Antibiotics must, however, be used with care as they are not without their own dangers and excessive use can lead to the development of resistant organisms, particularly staphylococci, or of fungus infection of the lung.

Treatment of paranasal sinus

For any associated paranasal infection local conservative treatment is given to provide as much as possible for adequate drainage, especially of the maxillary antra. An initial antral puncture and washout may be necessary in order to gain control but more extensive procedures are not indicated.

Assessment of treatment

The results of maintaining the patient on a medical regime may be assessed after some weeks or, in the case of children, after some months. Further

bronchography may be desirable particularly where cylindrical dilatation was prominent on the original bronchogram.

Surgical treatment

Where possible, removal of the affected portion of lung is indicated; there are, however, several contra-indications to surgery.

Contra-indications

Old age.—Few patients survive to old age with bronchiectasis, but 60 years is regarded as the upper age limit for resection as lung function has by this time diminished considerably and operation has become hazardous. Resection may sometimes be possible, however, where the bronchiectatic lobe is shrunken, atelectatic and functionless.

Extensive disease.—Bilateral resections of large volumes of lung on each side are well tolerated in children and in adolescents; for example, the lower lobe and the lingula may be removed on the left side and the lower lobe on the right side with little ultimate diminution of pulmonary function as the remaining lobes will hypertrophy. In adults, however, extensive resections are in most cases contra-indicated but lung function can be a guide in this matter.

The allergic child.—Patients with asthma or a strong allergic history are generally unsuitable for surgery. The type of bronchiectasis seen on the bronchograms is diffuse and often involves widely separated segments. These children are troubled more by asthma than bronchiectasis although they do tend to have recurrent attacks of pneumonitis. It has been found that resection has very little effect on their symptoms or on the frequency of the attacks of pneumonitis.

Recurrent pneumonitis in non-bronchiectatic areas.—Patients presenting this feature who also have persistent rales and rhonchi in parts of the lung remote from the main bronchiectatic area must be viewed very cautiously and surgery only undertaken if it is certain that the bronchiectatic lung is responsible for the production of an excessive amount of sputum and where medical treatment has failed completely to control the symptoms

The chronic bronchitic child with bronchiectasis.—These children present special problems and if operated upon are seldom improved clinically; furthermore, post-operative atelectasis and the development of new bronchiectatic areas is common. This group should be recognized and surgical treatment avoided.

Preparation for surgery

Medical treatment must be intensified in the days prior to operation, prolonged tipping applied and a full course of a suitable antibiotic given with the aim of reducing the volume of sputum to a minimum. Antral puncture and the temporary insertion of fine polythene catheters as a route for washouts is recommended for associated sinusitis

Surgical management

Radical surgery

There have been no particular advances in the technical aspects of the operation for bronchiectasis. The diseased area must be removed completely by segmental resection, lobectomy or pneumonectomy, and normal lung in the vicinity of the

disease should be preserved. However, in many cases of bronchiectasis the disease is confined to the basal segments of the lower lobe, the apical lower segment being normal, and a decision has to be made whether or not to remove this segment with the rest of the lobe. It is generally advisable, when the disease is as localized as this, that the apical lower segment should be resected with the rest of the lobe because there is a relatively high incidence of post-operative atelectasis and delayed expansion, with a smaller incidence of bronchiectasis developing in this segment (Hoffman, 1955) Where bilateral resections are planned and in an older patient it is more important to preserve as much normal lung as possible and the risks of leaving this segment behind must be accepted.

Palliative surgery

The principle of complete removal of the diseased area does not always apply, for the problem that not infrequently arises concerns the adult patient who has one lung totally bronchiectatic and with a small amount of disease on the other side, and who has failed to respond to medical treatment. Such patients usually cough up very large volumes of sputum, often foetid, have difficulties with their employment and are sometimes social outcasts. Palliative resection of the most severely damaged area, although hazardous, is rewarding as the volume of sputum now produced becomes very much less.

Bilateral surgery

This is more often indicated in children than in adults. The more severely involved side should be treated first and the second operation undertaken several months later after a period of convalescence.

Post-operative management

Early complete expansion of remaining lung is vital after lobectomy or segmental resection for bronchiectasis Atelectasis due to sputum retention may occur at any time during the first week after operation and every effort must be made to avoid it by active breathing exercises and by adequate coughing, and to treat it immediately by bronchoscopy should it occur. In adult patients with very poor respiratory function there is a place for deliberate tracheostomy, carried out on completion of the pulmonary resection. This provides a readily available route for removal of bronchial secretions by suction, and will improve ventilation. It can be maintained for the first week or 10 days after operation.

Results

The mortality rate for operations for bronchiectasis has steadily declined owing to the much improved case selection and pre-operative preparation. It is now under 3 per cent.

The surgical result is generally excellent, in most cases the patient is made free from cough and sputum and attacks of respiratory infection. In some cases slight cough and purulent sputum persist in spite of removal of all the diseased area and an uncomplicated post-operative course. This picture is due to a mild tracheo-bronchitis and it can usually be cured by giving a maintenance dose of an antibiotic for some months, after which time the natural resistance of the bronchial mucosa to infection is re-established.

Unsatisfactory results

Persistence of cough and sputum with recurrent episodes of pulmonary infection occurs in about 10 per cent of patients who have been operated upon for bronchiectasis. Generally less satisfactory results are obtained in children than in adults and this has prompted a much more conservative attitude to the disease in children, postponing surgery until it is quite established that a conservative regime is not halting steady deterioration in the child's condition. Where there is associated sinusitis an unsatisfactory result becomes more likely; although only a third of patients with bronchiectasis have sinusitis, analysis of those with persistent symptoms after operation showed that half had sinusitis (Ginsberg and his colleagues, 1955). Stress has already been laid on the poor results obtained by surgery in patients with an allergic or bronchitic background.

Recurrence of bronchiectasis, which must be distinguished from incomplete removal of the disease, develops most often as a result of post-operative atelectasis (Chesterman, 1957). When this has occurred further surgery is indicated provided there are no obvious contra-indications

The very best results are obtained in those patients with shrivelled, atelectatic lobes and generally much less satisfactory results where the lobe is normally expanded.

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ABSTRACTS RELATING TO THORAX

MALIGNANT DISEASE OF THE THORACIC AND ABDOMINAL OESOPHAGUS

Oesophageal diverticula

MUSTARD (1957 [illegible] of oesophageal diverticula. The most important lesions [illegible] and 8 epiphrenic [illegible] ; some [illegible] minimal [illegible] ation of [illegible] rough a [illegible] by forced feedings for [illegible] through a gastrostomy under local analgesia Oral [illegible] clear fluids for 48 hours before operation to ensure [illegible] re must be taken to avoid early recurrence from incomplete excision of the sac or stenosis of the oesophagus from over-generous removal

They tend to be larger than the epibronchial type, and are usually globular in shape with a relatively narrow neck. One epiphrenic diverticulum has been recorded as containing a carcinoma One patient had massive bleeding, which apparently came from the diverticulum; this complication has been previously recorded, as have others such as perforation, oesophagobronchial fistula and lung abscess The procedure of choice is

Gastro-oesophageal junction

Combined cineradiographic and manometric study

BOTHA, ASTLEY and CARRÉ (1957) described a combined cineradiographic and mano-

withdrawal pressure curve relative to the diaphragm, the hiatus and the gastric fundus. In 64 per cent the pressure curve showed a "saw-tooth" shape; 11 per cent showed an initial rise assuming a "plateau" shape; the remaining 25 per cent showed no initial rise,

over which pressure changes took place tended to be shorter during inspiration and the point at which the descent to general intrathoracic pressure began tended to be lower in position, though the reverse was sometimes seen. The results suggest a mechanism

mechanism although, particularly in abnormal subjects, other factors may play a part.

Total oesophagectomy

Reconstruction using right half of colon

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and to the left of
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the second stage is carried out. After exploring the abdomen for metastatic carcinoma, the caecum and right half of the colon are mobilized; the ileum and transverse portion of the colon are cleared where division is to take place; and the oesophageal stump is

gastrostomy is performed, as high on the stomach as possible, on the anterior surface. An end-to-end ileotransversostomy is then done to resore continuity of the bowel. Seven patients have survived to date of this report. Four are without evident recurrence and can eat relatively normally after closure of their gastrostomy. Two have complications

artery.

Resection of oesophagus

Reconstruction using aortic graft

SMITH and RAISON (1957) described, in a preliminary report, a method of restoring continuity following resection of carcinoma of the oesophagus with aortic graft replacement. The reasons for adopting this technique derive from (1) the application of a number of observations made during a two-year trial of the method of polythene tube replacement for lesions of the mid-oesophagus, and (2) a study of earlier work on means of restoring continuity by foreign material. In 12 patients operated on in the two-year trial results were disappointing; deaths occurred from leaks from the ends of the tube, lung abscess from inhalation of regurgitated stomach contents up the tube, and pressure by the tube on
right rib is
oesophagus
it is sutured
growth is resected with any lymph nodes that can be reached. Any required shortening of the graft is taken from the end of lesser diameter. This end is sutured to the lower end of the oesophagus, the lower end is anastomosed first. Absolute haemostasis of the bed in which the graft is to lie is essential. The upper end of the graft, trimmed to an exact

3 cases in which the method was used In one the patient died from bronchopneumonia after 4 months' normal swallowing; in the two others normal swallowing occurred from the tenth and sixteenth days after operation respectively.

Reconstruction in children using colon

SHERMAN and WATERSTON (1957) described 2 methods of oesophageal reconstruction, using intrathoracic colon, in children The first (devised by Waterston) is reconstruction

result in a hernia nor so small that it causes vascular obstruction.

(Sherman's) uses right colon transplanted iso-peristaltically in the retrosternal position At the initial emergency procedure in infants with oesophageal atresia or tracheo-oesophageal fistula reconstruction is delayed; the cervical oesophagus is brought out in the

transverse colon transplant, at least 1 patient has required a subsequent operation for revision of a stenosis at the cervical anastomosis. The authors differ as to whether cervical anastomosis should be done at the initial reconstruction or at a subsequent stage.

Laryngopharyngeal and upper cervical oesophagus defects

Artificial bridging materials

The use of artificial materials in the bridging of laryngopharyngeal and upper cervical

"takes" were so poor that they appeared to be of little value. A cylindrical moulded

one operative death resulting from haemorrhage from a large pharyngeal vein; apart from this the immediate results appeared satisfactory The tubes were eventually dislodged in 8 cases, fistulas occurred in 5 cases but closed spontaneously in all but 1 instance. The one complication for which there was no effective countermeasure was recurrent cancer; after 3 years only 1 of the patients was free from cancer, and after 4 years he also had cancer. These results indicate that in the case of such extensive growths little increase in the salvage rate can be expected.

Cicatricial stenosis of oesophagus

Retrosternal transposition of isolated colonic loop

CHRYSOSPATHIS (1957) described 5 cases of extensive cicatricial stenosis of the oesophagus treated during the past 2 years by retrosternal transposition of an isolated colonic loop Each patient had swallowed sulphuric acid or potash at periods varying from 10 days to 1 year before admission to hospital. In all the cases the colon was used to

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colic artery which extended to the caecum In the other 4 cases the right half of the colon was pedicled on the right artery. Continuity of the intestinal tract was re-established in

4 cases by an ileotransverse side-to-side anastomosis, and a side-to-side colocolostomy of the ascending with the sigmoid portion of the colon in 1 case. One ...
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PROGRESS IN PULMONARY SURGERY

Large air cysts of the lung

Diagnosis and surgical treatmen...

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Bronchial adenoma

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indicated at bronch...

space; the cell nuclei are round or oval, and have dense nuclear chromatin or are vesicular with small dense nucleoli; the cells are characteristically uniform; mitotic figures are seldom observed The tumours are much more frequent in women than men, and the age distribution is usually below 40 years, clinical aspects include an unusually long duration of symptoms along with the maintenance of comparatively good health. The most frequent symptoms are cough and haemoptysis, and other symptoms arise as a

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obectomy or

Carcinoma of the lung

Diagnosis by biopsy and cytological smears

The diagnosis of lung cancer by bronchoscopic biopsy, scalene lymph node biopsy, and cytological smears was discussed by UMIKER, DE WEESE and LAWRENCE (1957). A study was made of 42 patients with histologically proved lung cancers; 38 of the patients

celled carcinomas or carcinomas of the lower lobes, while 50 per cent of the patients with undifferentiated-celled or gland-celled carcinomas and who had lymph node biopsies were found to have metastatic involvement of these nodes; in 4 out of 7 cases in which the result of biopsy was positive this finding provided the only criterion of inoperability. Although cytological examinations were least successful in cases of carcinoma of the upper lobe compared with cases of tumours of the lower lobe or of the main-stem bronchi, the results in cases of upper lobe tumours represented a marked improvement on those obtained with bronchoscopic biopsy The diagnostic triad produced a pre-operative diagnosis of carcinoma in 90 per cent of the series, and the authors now use, routinely, all 3 methods simultaneously, except when any of the procedures are contra-indicated Although it has been claimed that there is no positive correlation between cytological findings and resectability, in the present series only 27 6 per cent of cases with positive smears were resectable, while 80 per cent of the patients who had negative smears underwent lobectomy or pneumonectomy

Involvement of the thoracic wall

GRONQVIST, CLAGETT and MCDONALD (1957) presented a study of 16 cases of bronchogenic carcinoma with involvement of the thoracic wall The series comprised 13 males and 3 females, whose ages ranged from 35–82 years; the type of carcinoma was large cell in 6 cases, squamous cell in 6, adenocarcinoma in 3 and mucous adenocarcinoma in 1 case The intercostal nerves and vessels were involved in 12 cases and the brachial plexus in 1 ; in 3 cases only the parietal pleura was involved Pneumonectomy was performed in 7 cases and lobectomy in 9, the involved part of the thoracic wall was removed simultaneously in all cases The most prominent symptom was pain, the duration of which

ranged from 2 weeks to 15 months; there were no cases of

up was complete

6 surviving patie

6½ years respectively, the carcinoma did not extend into the intercostal muscle bundles in either of these patients; the third patient who had involvement of the parietal pleura only was living 13 months after the operation. A review of recorded data suggests that peripheral bronchogenic carcinoma with involvement of the thoracic wall may have a favourable prognosis if there has been no spread by the lymphatic system or blood vessels of the thoracic wall; apparently there is a

to be a particularly grave prognostic sign.

Results of raising the resectability rate

SMITH (1957) discussed the results of raising the resectability rate in operations for lung carcinoma. In the author's series of cases an attempt to remove the lung containing the growth, whatever its local extent, was prompted by three main principles: that surgical

and palliative in 48. The most significant feature peculiar to the palliative operation is

finally on the state of the main bronchus, especially on the left side, resectability should be determined by pre-operative bronchoscopy to assess the involvement of the carina, main

which would have been excluded earlier; this tendency to increase the scope of the operation appears to be undesirable.

Pulmonary tuberculosis

Results of thoracoplasty

GOUGH and his co-workers (1957) discussed the results of thoracoplasty in the treatment of pulmonary tuberculosis. The evaluation of thoracoplasty necessitates the following requirements: (1) the series should consist of a large number of patients, operated on consecutively by a standard procedure; (2) the operations should be carried out under the best and most modern conditions, (3) all the patients should be followed up for at least 5 years post-operatively, (4) accurate and detailed information should be given about the pre-operative condition of the patient, particularly as regards type and extent of disease; (5) the terms used such as "active" and "quiescent", should be precisely defined; (6) there should be a control series exactly comparable except that no operation is performed;

months of the operation; there were post-operative complications in 43 cases; the follow-up periods ranged from 6 to 8 years. At the end of the observation period 82 per cent

were quiescent, 3 per cent had active disease, 14 per cent were dead, and 1·3 per cent

Results of lung resection

BICKFORD and his co-workers (1957) presented a critical review of the results of lung resection for pulmonary tuberculosis. A total of 1,575 patients had pulmonary resection

survey was made of the first 399 cases per-
ese cases comprised 3 groups, as follows:
195 treated by lobectomy; and (3) 75 cases
of a 5–9 year follow-up were: group 1:
dence of disease or disability, 11; dead, 5;

tuberculous pyothorax prompted the authors, in later years, to perform thoracoplasty in cases of pneumonectomy, in an attempt to obliterate the pleural cavity. The minor complication of microfistulae was the most frequent after resection, and was not usually of serious consequence. The development of new areas of disease in the post-operative phase or later was apparently rare unless a tuberculous pyothorax had ruptured into the lung. In older patients, the incidence of infection is generally higher, if the pulmonary function is in doubt in these cases, the authors perform a thoracoplasty in preference to resection. Experiences suggest that resection can be performed in younger patients without increased risk of re-activitation provided it is performed only on carefully selected

operation, either at the same time or later, is obligatory.

Thoracic actinomycosis

BATES and CRUICKSHANK (1957) reviewed the subject of thoracic actinomycosis, because of the radical change in therapy, and the improvement in mortality rate, that have taken place in recent years The methods of treatment used have included vaccines, iodine,

the adjacent lung substance, and have no details of a case presenting initially as a bronchopneumonia, they omit the bronchitic and bronchopneumonic *varieties from their* classification The cause of a primary lung infection is either inhalation from within the mouth, or spread through the blood stream, of the fungus *Actinomyces israeli: infection from the tonsils is an important factor in younger patients and dental sepsis in older* [illegible]

combined with pulmonary tuberculosis in 2 cases. The disease is especially prevalent in Europe and America: of the 85 patients with pulmonary infections, 80 were town dwellers and 5 were country dwellers. Approximately 15 per cent of infections affect the thorax, it is more common in men than in women, and most cases occur after the age of 20 years. Microcytic anaemia is a common complication, and cerebral abscess, pyaemia, and amyloid disease occur less frequently The only diagnostic physical sign is the nature of the chest wall sinus, which tends to heal temporarily, and then breaks down and discharges again The most common presenting symptom is pain: cough and purulent sputum appear at some stage; the only characteristic radiological appearances are those that result from bone change. Of the present series of patients 30 received surgical treatment, 20 had empyema, 7 were treated by lung resection.

Ventilatory insufficiency

Treatment by tracheostomy and artificial ventilation

The treatment of ventilatory insufficiency by tracheostomy and artificial ventilation was discussed by BJORK and ENGSTRÖM (1957). In the authors' technique a tracheostomy is performed, and then an airtight connexion between the lungs and the respirator is established through an ordinary silver cannula provided with a rubber cuff: there has been no instance of pressure necrosis or tracheo-oesophageal fistula, air leakage around the cuff can be detected by measuring the insufflated and exsufflated gas; the volume-cycled (Engstrom) respirator with positive-negative airway pressures is used; frequent aspirations through the tracheostomy, and careful supervision during and after treatment, [illegible]

SURGERY OF CARDIAC SEPTAL DEFECTS

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The development of techniques allowing visual intracardiac surgery with ever decreasing risk has recently enabled the most striking advances to be made in the correction of septal defects.

The overwhelming majority of these defects are congenital in origin although an interventricular communication may be acquired following a myocardial infarction that involves the septum.

ATRIAL SEPTAL DEFECT

Anatomy and haemodynamics

Atrial septal defect is the most common isolated congenital cardiac abnormality. The commonest type is a persistent ostium secundum found in the dorsal part of the septum. It may be completely surrounded by a septal rim but sometimes this is absent posteriorly so that the right pulmonary veins appear to be draining into the right atrium. Large defects may extend to the inferior vena cava and may lie astride the caval orifice and if a well-developed eustachian valve is present the vena cava may appear to be draining into the left atrium. A less common variation is the sinus venosus defect located high in the septum in the region of the superior vena cava. Anomalous pulmonary venous connexions may occur with the vena cava or the adjoining right atrium There may be multiple defects (Fig. 53).

These anatomical variations and their practical importance to the surgeon have been well described by Bedford and his colleagues (1957).

About 10 per cent of atrial septal defects are due to persistence of the ostium primum (Fig. 54). These are large, and involve the anterior part of the septum. They are almost always associated with a cleft aortic mitral cusp or medial tricuspid cusp or both. There may be a coexisting ventricular septal defect and in every case there is an absence of septal tissue between the atrial deficiency and the endocardial cushion between the atrioventricular valves.

Rogers and Edwards (1948), and Wakai and Edwards (1956), classified septum primum defects as incomplete or complete types of common atrioventricular canal In both there is an interatrial communication. In the latter there are abnormalities of both atrioventricular valves and a ventricular septal defect The incomplete type falls short of this extreme. Apart from convincing embryological and anatomical



Fig. 53 —Specimen showing a large atrial septal defect (A), and a separate fenestrated opening (B) An Ivalon prosthesis (C) has been used to close a coexisting ventricular septal defect



Fig. 54.—A specimen showing a persistent ostium primum from the right atrium. (A) Tricuspid opening (B) Cleft endocardial cushion (C) Bifid aortic mitral cusp, (D) Atrial septal defect.

reasons for this nomenclature it serves to emphasize the valvular and ventricular component of this complex abnormality. This is of considerable practical importance for, whereas defects confined to the atrial septum may be closed by direct suture using the limited time provided by hypothermia, an extracorporeal circulation is necessary when a plastic prosthesis is required to close a large primum defect, and when valvular abnormalities and possibly a ventricular septal defect require correction at the same time.

The shunt through the defect is from left to right and results in a greatly increased pulmonary blood flow. Even with large flows the pulmonary artery pressure may remain within normal limits, but ultimately changes in the pulmonary arterioles and thrombosis increase the pulmonary vascular resistance and the pulmonary arterial pressure rises. This impedance to blood flow may result in a decreased shunt and if pulmonary arterial pressure approaches the systemic pressure the shunt may cease or even reverse producing central cyanosis. The right ventricle reacts by hypertrophy and may ultimately fail.

Clinical features and special investigations

Atrial septal defect is more common in females than in males, rarely gives rise to symptoms or complications in childhood unless of the ostium primum variety, and indeed is *frequently not recognized at that time.*

[illegible] hypertension

[illegible] de The radial

[illegible] *outflow tract* of the enlarged right ventricle and dilated pulmonary artery. Many cases have a pulmonary systolic murmur with fixed splitting of the second sound, and less often a diastolic murmur due to functional pulmonary incompetence, but murmurs, particularly in children, may be inconspicuous. There may be a tricuspid diastolic murmur due to increased flow through the valve. A radiograph (Fig 55) shows dilatation of the pulmonary artery with well-marked pulsation on screening, pulmonary plethora, enlargement of the right side of the heart, particularly the right atrium, and *hypoplasia of the aorta. Electrocardiographs show partial or* co [illegible]

inc[illegible] easily from right to left through the defect. The pulmonary blood flow may be [illegible] or four times the systemic flow without producing pulmonary hypertension, but when the latter is present it is important to calculate the relative importance of flow and vascular resistance in its production.

This condition is frequently accompanied by anomalous pulmonary venous connexions to the right atrium, venae cavae or coronary sinus. Tomography may suggest these complicating lesions and the catheter tip may enter such veins and demonstrate *their presence and position Selective angiocardiography* is not usually helpful but dye dilution studies are of value in showing their existence. For the diagnosis of anomalous pulmonary venous connexions Evans blue dye is injected into each pulmonary artery via a cardiac catheter.

An ear oximeter employing a photo-electric cell can be used to pick up variations

in dye concentration This can be coupled to an amplifier and a pen recorder to write a time concentration curve

An injection into the left lung (Fig 56) which has normal drainage results in a normal dye curve with a short appearance and disappearance time. By contrast, an injection into the right lung, whose veins drain into the right atrium, results in a curve with a prolonged appearance time, a small deflection and a prolonged disappearance time due to recirculation of blood through the right side of the heart.



FIG 55—Radiograph of a patient 30 years of age, with gross pulmonary hypertension The pulmonary artery is dilated and the right side of the heart is enlarged.

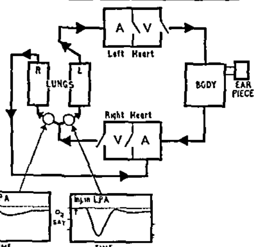


FIG. 56—Diagram showing the dye concentration curves obtained after injection of Evans blue dye into the right and left pulmonary arteries in a case in which the right pulmonary veins have an anomalous connexion with the right atrium.

Other abnormalities sometimes associated with atrial septal defect are mitral stenosis and right ventricular outflow tract obstruction. Atrial fibrillation is a fairly common complication.

Selection of cases for operation

The diagnosis is usually made during the second and third decades of life. Operation is indicated in those patients in whom the pulmonary blood flow is more than twice the systemic flow even when symptoms are absent. When pulmonary hypertension is associated with very high flows the need for operation is urgent. If the hypertension is due to increased pulmonary vascular resistance and the shunt is balanced or even reversed from right to left, operation can do no good. The presence of severe systemic hypertension is usually regarded as a contra-indication.

The hazards of operation are naturally greater in patients over the age of 40 years with irreversible myocardial damage.

The need for an accurate pre-operative diagnosis, particularly as to whether the defect is confined to the atrium or is part of a common atrioventricular canal, is essential, because the latter can be effectively corrected only by using a heart-lung machine with cardiac by-pass.

Points favouring a diagnosis of common atrioventricular canal are as follows.

(1) [illegible]
(2) [illegible]
(3) [illegible]
(4) [illegible]
(5) [illegible] an ostium secundum defect and [illegible] od, 1956).
(6) [illegible]

Although in general symptoms and complications occur earlier in patients with common atrioventricular canal which is complete, survival to even the fourth decade is possible with the incomplete variety so that minimal disability and an older patient does not necessarily exclude the diagnosis. Despite thorough investigation it may still not be possible to be sure of the exact nature of the abnormality before operation.

Choice of surgical technique

Closed methods

These include those in which the defect is first localized by palpation with the finger inserted in the right atrium followed by blind closure with uninterrupted flow through the heart. Various ingenious techniques have been described by Cohn (1947), Murray (1948), Swan and his colleagues (1950), Hufnagel and Gillespie (1951), Sondergaard (1952), and Bailey and his colleagues (1953). However, the varying anatomy of the defects, the difficulty of precise localization by palpation even by the most experienced operator, and the hazards of blind suture, mean that despite some successes such methods may be inaccurate, incomplete or impossible.

Semi-open method

The use of a rubber well stiffened at its upper rim and sutured to an opening in the dilated right atrium, made distal to a temporary clamp, was described by Gross and his colleagues (1953). Blood rises in the well and palpation of the defect and its suture is effected blindly through the blood which rises to a varying height within the rubber chamber. Because the atria are distended direct suture may be impossible so that a plastic prosthesis is frequently required to close the defect. It is more accurate than the wholly closed methods but demands training and extreme palpatory skill. Kirklin, Ellis and Barratt-Boyes (1956) described the technique in great detail and reported 74 cases with 3 deaths and a high percentage of apparently perfect results.

Open methods

Repair under direct vision is now the method of choice.

Hypothermia.—There is no doubt that for simple defects allowing rapid closure by direct suture this is a most satisfactory means of achieving conditions for open atriotomy in a dry field. Whatever method of cooling is employed, the ideal body temperature is about 30°C. or slightly above, controlled so that the temperature is just beginning to rise during cardiotomy. This allows venous inflow occlusion for about 8 minutes with safety. The risk of irreversible ventricular fibrillation is small, but rises rapidly if cooling is carried below this temperature.

Surgical method.—A wide exposure is required. With the patient supine and the arms extended, a trans-sternal bilateral thoracotomy is performed at the level of the fourth intercostal spaces through a transverse incision under the breasts. An incision is made in the pericardium parallel to the left phrenic nerve and curving at each end to form a flap held by stay sutures over the right lung. This exposes the dilated right atrium and hypertrophied right ventricle. The venae cavae are mobilized and encircled by tapes (Fig. 57). A search is made for a left superior vena cava which, if present, usually drains into the coronary sinus. If this is not temporarily clamped there will be considerable coronary sinus flow when the heart is opened. The index finger is inserted into the right atrium through a stab incision in either the atrial appendage or the main chamber, controlled by a purse-string suture. The position and size of the defect is defined with its relationship to the pulmonary veins and the venae cavae. The mitral valve is examined for evidence of stenosis which can be corrected at this stage. The presence of incompetence at the mitral or tricuspid valve is shown by a regurgitant jet.

Obstruction to the outflow tract of the right ventricle may be gauged by a finger hooked through the tricuspid valve.

When the diagnosis of a defect confined to the atrium has been confirmed, a long clamp is placed on the atrial wall, which is incised, and stay sutures are inserted. An unclosed clamp is placed across the aorta and pulmonary artery. The inferior vena cava is then occluded followed by the superior vein. Fifteen seconds later, when the heart has expelled most of its blood, the aortopulmonary clamp is closed at the root of these vessels to prevent coronary air embolism during the period of cardiotomy. Some surgeons place tourniquets around the lung roots to prevent blood leaking into the heart via the pulmonary veins. The clamp is removed from the

right atrium and blood removed by suction. The defect is then exposed and sutured with a continuous stitch of silk beginning at the lower end to minimize the danger of distortion or even inclusion of the inferior caval orifice. Additional defects are searched for and repaired, but before the final closure Ringer's solution or saline solution is poured into the cavity to displace air in the left atrium. Temporary loosening of the caval tapes results in air being expelled from the right atrium and ventricle by returning blood. The atrial clamp is then replaced and the pulmonary venous tourniquets and aortopulmonary clamp are quickly released. The superior vena cava tape is loosened and that on the inferior vein more slowly as the heart recovers tone. If ventricular fibrillation occurs, electrical defibrillation is required and cardiac massage is carried out until a satisfactory heart action returns. The

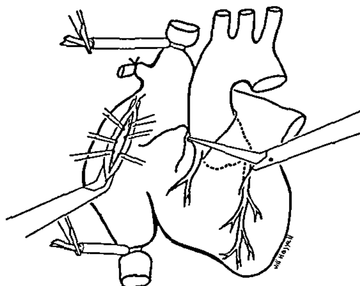


FIG 57.—Diagram showing the heart just before the closure of a simple atrial septal defect An incision distal to a clamp has been made in the right atrium and stay sutures have been inserted The venae cavae have been occluded and a clamp placed across the root of the aorta and pulmonary artery.

atrial incision is repaired, the pericardium is loosely sutured, and the chest closed with bilateral pleural drainage.

Re-warming is carried out by means of a heating blanket.

Results of operation

Lewis and Taufic (1953) reported the first successful closure of an atrial septal defect using hypothermia

Swan and Blount (1956) described 45 patients in whom hypothermia was employed in the repair of secundum defects. Of these 7 died, and of the survivors 26 of 27 who have been re-catheterized are cured. This series includes many cases which would not now be considered suitable for operation and of course the usual calamities which befall the surgical pioneer.

Bedford and his colleagues (1957) reported 40 patients operated upon by Sellors in a similar way with but 1 death and this followed re-operation. Of 12 patients re-catheterized 10 have either no shunt at all or one which is insignificant.

Provided that there is good selection of cases and careful hypothermia the mortality in centres familiar with this field should be about 5 per cent.

Extracorporeal circulation and atrial septal defect

The results of open heart surgery are everywhere so good when hypothermi employed that the use of a heart-lung machine with cardiac by-pass is not necess in the closure of defects confined to the atrial septum.

Common atrioventricular canal

An extracorporeal circulation is demanded for the correction of common at ventricular canal Details of the preliminary surgical steps required to establ cardiopulmonary by-pass were given by Drew (1957)

Before cannulation of the great veins, a preliminary digital exploration of right atrium is carried out to determine the extent of the defect and to establish degree of regurgitation through each atrioventricular valve. When cardiopulmon by-pass has been established and the heart arrested by potassium citrate, a lo incision is made in the right atrium and blood removed by suction. The leaflets both valves are inspected for abnormality and raised to disclose any ventricu septal defect which may be present. This is repaired with interrupted silk sutu Clefts in the aortic mitral cusp and the medial tricuspid cusp when present are th obliterated in a similar way.

The atrial septal defect is usually so big that a patch of polyvinyl sponge (Ival or Prosthex) is required to close it. This is anchored to the margin of the def including the bare area of the ventricular septum at its lower part Cooley a Kirklin (1956) described details of the technique employed and reported the rest of surgery in 12 patients, 9 of whom were operated upon using the Gibbon hea lung machine. There were 9 survivors with excellent clinical results One fatal occurred in a patient in whom the defect was closed but whose mitral incompete was uncorrected It was considered likely that this was the cause of death.

VENTRICULAR SEPTAL DEFECT

Anatomy and haemodynamics

Ventricular septal defect commonly occurs as an isolated lesion but because septum has a complex embryological origin there are variations in its size a position These range from the very small communication producing auscultatc evidence of a defect with little or no shunt demonstrable at cardiac catheterizati (maladie de Roger), to complete absence of the septum with a single ventricle.

Excellent detailed accounts of the varying anatomy have been given by Becu a his colleagues (1956) and by Warden and his colleagues (1957).

By far the most common type of defect is related to the pars membranacea, t frequently this structure is partly or wholly present so that much of the deficier is at the expense [illegible]
supraventricular [illegible]
aortic valve cusp [illegible]
present above the crista supraventricularis just below the pulmonary artery, a when viewed from the left is found in relation to the left aortic cusp. A less comm situation is beneath the septal cusp of the tricuspid valve. Even more rare is deficiency low down in the muscular part of the septum. The deficiencies may

multiple. The most frequent associated lesion is an obstruction to the outflow from the right ventricle, either infundibular or valvular stenosis or both (Fallot's tetralogy). Other fairly common associated abnormalities are a persistent ostium secundum, patent ductus arteriosus and coarctation of the aorta.

The shunt through an isolated defect is usually from left to right, but the effect on the pulmonary vasculature is more serious than similar shunts at other levels. This is probably due to the pulsatile thrust of the left ventricle discharging part of its contents through a high defect directly into the pulmonary artery.

Pulmonary hypertension with vascular damage may develop in infancy. A shunt at ventricular level throws an increased burden on the left ventricle, but in the presence of a raised pulmonary artery pressure both chambers may hypertrophy.

Clinical picture and special investigations

The characteristic clinical features are a small or normal pulse, a cardiac impulse which is left ventricular in type, and a systolic thrill and murmur which is usually maximal in the third and fourth intercostal spaces at the left sternal border. In severe cases there is a mitral diastolic murmur owing to increased blood flow through the mitral valve.

On purely clinical grounds it may be difficult during early life to differentiate between this condition, atrial septal defect and patent ductus arteriosus. The electrocardiogram may be normal or may show evidence of left ventricular enlargement, while in severe cases both left and right ventricular hypertrophy are present.

Radiographs show, in all but mild cases, dilatation of the pulmonary artery, left ventricular enlargement and pulmonary plethora (Figs 60 and 61).

The diagnosis of maladie de Roger is now confined to those cases with a loud systolic murmur and possible thrill who are symptomless, whose electrocardiogram and radiographs are within normal limits, and in whom cardiac catheterization demonstrates little or no shunt.

Cardiac catheterization is carried out to confirm the diagnosis and to estimate the degree of shunt and the pulmonary vascular resistance

Angiocardiography, even if of the selective type, gives little additional information unless it is suspected that other lesions are present. There may be no symptoms and the prognosis is good in very mild cases except for the ever present danger of bacterial endocarditis. However, a large number of patients develop cardiac failure in infancy with a high mortality from this and superadded pulmonary infection, and others develop these complications later in life

Marquis (1950) described in detail the clinical picture in 4 children under the age of 3 years, 2 of whom died. He quoted 110 consecutive cases of congenital heart disease coming to autopsy during the first 3 years of life of which 28 had isolated ventricular septal defect This represented the commonest single lesion in the series The malignant nature of the abnormality, particularly in childhood, was confirmed by Becu and his colleagues (1956)

Selection of cases for operation

This problem is by no means settled. Operation for patients with true maladie de Roger is not justified. Cases in whom a high degree of pulmonary vascular resistance is associated with a balanced or reversed shunt are inoperable.

The most urgent need for surgery exists in those under 2 years of age in whom cardiac failure is common Unfortunately, there is a high mortality following surgery in this age group which is not completely understood. One factor which undoubtedly plays a part in the poor results is the difficulty in maintaining constant circulating blood volume and biochemical control during and after cardiopulmonary by-pass in such small patients. Post-operative pulmonary complications after bilateral





FIG. 59 —Same specimen as in Fig 58 viewed from the left ventricle. The defect (A) closed by the prosthesis, *is just below the aortic valve (B).*

thoracotomy are also difficult to manage in infancy. However, many may be tided over episodes of cardiac failure and pulmonary infection by appropriate medical measures until the age of 3–5 years when surgery can be undertaken with less risk. In those that fail to respond surgery is justified but the hazards are great. Above the age of 2 years indications for operation are failure to thrive, dyspnoea and frequent pulmonary infections, a pulmonary blood flow which is greater than twice that of systemic flow and electrocardiographic and radiographic evidence of increasing cardiac strain.

Abnormalities such as atrial septal defect, patent ductus arteriosus and coarctation of the aorta should be corrected at the same time.

Patients with Fallot's tetralogy need special consideration and are not discussed here.

Surgical methods

Murray (1948) was the first to attempt the correction of ventricular septal defect. His method consisted in passing fascia lata strips across the defect in the plane of the septum from outside the heart. The free ends were anchored to the epicardium. He claimed some success, but the variation in the position and size of the lesion and its close proximity to the aortic valve cusps demands careful intracardiac surgery under vision. The only means at present available to fulfil this necessity is the extracorporeal circulation with cardiopulmonary by-pass. Many different heart-lung machines are now in use and their behaviour and the problems associated with them are discussed by numerous contributors to *Extra-Corporeal Circulation* (Allen, 1958).

Repair of ventricular septal defect using the extracorporeal circulation

With the patient supine, trans-sternal bilateral thoracotomy is carried out through the fourth intercostal space. A flap of pericardium is turned down and the diagnosis confirmed by palpation of a thrill over the right ventricle transmitted to the pulmonary artery. A large right atrium usually signifies an atrial septal defect overlooked at cardiac catheterization A search is made for a patent ductus arteriosus. In cases of doubt, blood pressure and oxygen saturation in the cardiac chambers, pulmonary artery and aorta can be determined. The patient is then heparinized. The venae cavae are loosely snared by tapes and cannulated via the right atrium or its appendage and the arterial cannula inserted into the left subclavian or femoral artery. These cannulas are then connected to the venous and arterial lines of the heart-lung machine

Total cardiopulmonary by-pass is established by starting the extracorporeal circulation and then tightening the snares about the cannulated venae cavae. A clamp is then placed across the aorta above the coronary arteries and the heart arrested by the injection of a potassium citrate blood mixture proximal to the clamp A long incision is then made in the right ventricle (Fig. 62) and stay sutures inserted in the myocardial edges to allow inspection of the chamber after the contained blood has been removed by suction. With the heart arrested, the blood returning to the heart is very small in amount and is confined to that from the bronchial circulation draining into the left atrium. The site and size of the defect is noted and its relationship to the tricuspid and aortic valves and the pulmonary

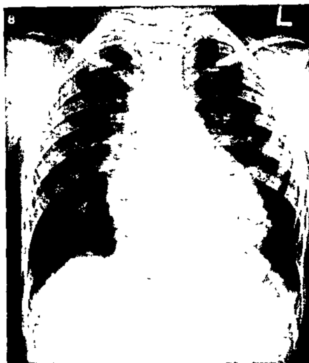
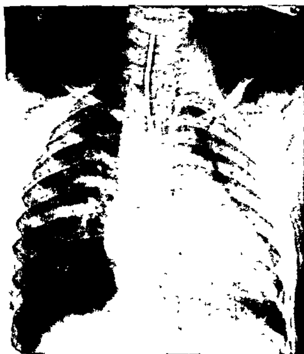


FIG 60



FIGS 60 and 61 —Radiographs of a girl aged 5 years with a ventricular septal defect The pulmonary artery is dilated and there is left ventricular enlargement A cardiac catheter is shown passing through the defect from right to left and thence into the aorta and innominate artery

FIG 61

artery. Small communications may be closed by interrupted silk sutures. A figure-of-eight stitch may have less tendency to tear through the fragile septal rim than a simple one. If the suture line is made in the direction of the right outflow tract it is then at right angles to the blood flow through the aorta as seen from the left ventricle and distortion of the aortic valve ring is minimized.

Considerable judgment is required to decide which lesions can be repaired satis-

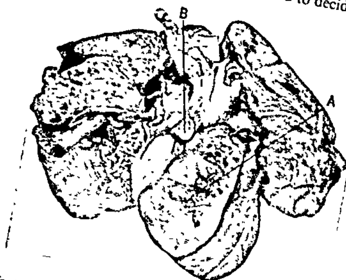


Fig 62.—Specimen showing a repaired right ventriculotomy incision (A) The right atrial appendage, used for insertion of the caval cannulas has been ligated (B)

factorily in this way because the powerful ventricular movements tend to cause dehiscence of the suture line in large defects. Their successful repair requires the insertion of a plastic prosthesis which consists of non-compressed or partly compressed polyvinyl sponge (Ivalon or Prosthex) cut to size and sutured in position. This may be achieved by interrupted circumferential stitches or a series of mattress sutures crossing in the plane of the septum from one side of the defect to the other and passing through the sponge.

When the closure has been completed the ventriculotomy incision is partially closed with interrupted sutures through the full thickness of the myocardium and the aortic clamp is removed The coronary circulation is thus restored and the heart quickly assumes normal rhythm. Coronary sinus flow following the period of arrest is always excessive and is removed by suction from the right ventricle and returned to the machine until the heart has completely recovered its tone. Repair of the ventriculotomy incision is then completed. The caval snares are released allowing some blood flow through the heart, and if it continues to behave satisfactorily the extracorporeal circulation is suspended and the cannulas withdrawn, with repair of the right atrium and the artery Protamine is then given slowly to reverse the effect of previous heparinization. The pericardium is loosely reconstituted and the chest closed with bilateral pleural drainage.

It is important that during the entire procedure careful measurements are made of blood loss and fluid replacement so that when the operation is completed the circulatory blood volume remains unaltered This may be checked by weighing the patient prior to and after the operation

Post-operative care and complications

Haemorrhage

This is no longer a serious problem in centres with experience in this field of surgery.

It may occur if blood used to prime the machine is incompatible or not freshly taken, or when there has been some technical error in assembling or operating the machine so that the blood circulating through it is subjected to excessive trauma. Constant attention must be given to the pleural drainage tubes so that blood loss within the chest can be measured as it occurs and instantly replaced.

Heart block

This serious complication may occur during the repair and is caused by trauma to the conducting bundle. An advantage of working within the beating heart is that this alteration in rate may sometimes be corrected by withdrawal of the offending needle or suture. However, the greater accuracy allowed by operating in the quiet and bloodless field of the arrested heart outweighs this consideration and indeed the overall incidence of heart block does not seem to be higher when a cardioplegic is used. If it occurs before the chest is closed Lillehei and his colleagues (1957) advise the use of a pacemaker connected to a wire electrode sutured into the myocardium and exteriorized within a fine plastic tube. A second needle electrode is inserted into the pectoral muscle The pacemaker is adjusted to a rate appropriate to the age of the patient and can be applied for a long period This method is preferable to the use of two external electrodes which produce much uncomfortable and sometimes painful muscle contraction. When normal rhythm has been established the internal electrode is removed by gentle traction

Some benefit is obtained by the exhibition of isoproterenol (Isupren) which may be given intravenously or as a linguet

Heart block occurs in about 10 per cent of patients in whom ventricular septal defect is repaired, of whom one-third ultimately die.

Pulmonary complications

These are more frequent and less easy to treat in young children.

They are less common if the patient is kept slightly dehydrated for 48 hours after the operation.

Tracheotomy should be carried out early in patients with much secretion, and in bad risk cases it is an advantage to do this 7–10 days before operation.

No serious complications have been reported following the use of a plastic sponge prosthesis but the follow-up period is obviously short

Results of operation

Lillehei and Kirklin have the greatest experience in this type of operation The former and his colleagues (1957) described the results in 154 patients. There were 45 deaths, or an overall mortality of 29·3 per cent. In 44 patients over the age of 2 years with a pulmonary artery systolic pressure less than 70 per cent of the aortic pressure, there were only 3 deaths and each of these had a significant associated lesion.

Catheterization of 36 patients 4–16 months after operation showed that in 28 there was no residual shunt and most of these showed a fall in pulmonary artery pressure. Five patients had a small shunt with a normal pulmonary artery pressure and 3 were not improved. These patients were treated early in the series.

Kirklin and his colleagues (1958) reported the results of surgery in 110 cases of ventricular septal defect with similar results.

There is no doubt that a favourable outcome is dependent upon intelligent selection of patients, a sound knowledge of the variation in anatomy of the defect, a team trained in the experimental laboratory, and meticulous post-operative care. If these factors are present the disease is curable and the mortality and morbidity will become increasingly less.

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ABSTRACTS RELATING TO CARDIAC SURGERY

Aortic valve surgery

Simultaneous pressure measurements

BAKST, COHEN and LOEWE (1957) described simultaneous pressure measurements in

aorta, left ventricle and left atrium were performed in 3 groups of patients: those with normal hearts, those with mitral stenosis, those with combined mitral and aortic stenosis.

and ventricle. Higher at the end of diastole, it is a measure of the physiological significance of the lesion. Following mitral commissurotomy it is abolished. In combined mitral and aortic stenosis the atrioventricular pressure gradient is similar to that in mitral stenosis In aortic stenosis the rise in aortic pressure is gradual and the valve closes almost immediately after the pressure peak is reached. After instrumental dilatation of the aortic valve there is a marked decrease in the ventricular-aortic pressure gradient. A change also occurs in the timing of the systolic phase of the cardiac cycle, due to the shortened time between

Aortic stenosis

Surgical treatment

BROCK (1957) discussed the surgical treatment of aortic stenosis and reviewed its

valvotomy under direct vision and with hypothermia is urged

mortality of 18 per cent. Mortality need be no more than 10 or 15 per cent but it will always be high if surgery is deferred too long

Mitral insufficiency

Encircling suture in surgical treatment

GLOVER and DAVILA (1957) described the use of an encircling suture in the surgical treatment of mitral insufficiency. The suture is placed round the ring of the mitral valve. When an accurate technique is employed no damage is inflicted upon the coronary circulation, the myocardium, the mitral valve or the cardiac conduction system. Criteria for the

missurotomy was also performed. Four patients were alive and in an improved condition

thick but pliable and the mural leaflet was contracted and immobile. After insertion of the suture the ventricles began to fibrillate. Effective ventricular contraction was resumed after various resuscitative measures had been adopted such as cardiac massage and multiple electric shocks. Despite the prolonged period of circulatory failure recovery ensued without any apparent ill-effects A woman, aged 19 years, had suffered from ... dyspnoea and chest pain. There was enormous enlargement of ... ating ... ined ... y by ... tres. ... f the suture.

Aortic valve prosthesis

Experimental study

ROE, NAJARIAN and MOORE (1957) described an experimental study in which a flexible aortic-valve prosthesis was inserted into the ascending aorta. The experiments were performed on animals at the normal body temperature. The prosthesis was a plastic cylinder with 3 shallow cusps resembling those of the aortic valve, and the material ... chloride plastic with a polymeric plasticizer. With reference to the ... was inserted into the ... in the distal thoracic ... orta and secured in place with mattress sutures of braided silk; then the catgut suture was withdrawn. The ... accomplished in less than 7 minutes of aortic occlusion and without ... at the cusps could withstand a ... material ... nd no ... de of ... but in time the valve failed to ... ransventricular avulsion of the anatomical valve cusps in conjunction with insertion of a prosthesis. This operation produced no untoward results.

Coronary artery disease

Auxiliary myocardial vascularization by prosthetic graft implantation

SMITH and his colleagues (1957) described auxiliary myocardial vascularization by prosthetic graft implantation. The technique, a modification of the method originally

patency confirmed The "apical" end of the transplant is trimmed and closure of the

anastomosis between the grafted vessel and the pre-existing coronary circulation. The

Myocardial vascularization by implantation of left common carotid artery

and drawn into the tunnel. The occluding clamp was removed and the vessel began to pulsate again. After the animals were sacrificed the artery was found to be patent in 28 cases. Thickening of the intima was often demonstrated, however, and this change was apparently due to fibrous organization of a thrombus. Injection techniques revealed vascular communications between the implant and the coronary arterial system, but the communicating vessels were of small calibre A polyvinyl catheter was inserted into the coronary sinus and the total flow was recorded by a rotameter The flow was determined before and after occlusion of the implant. No significant changes were observed. After ligation of the anterior descending coronary artery the survival rate was 64 per cent, whereas among control animals the rate was only 30 per cent. Evidently the implants afforded a measure of protection against ligation In another series of experiments a portion of a systemic artery was implanted into organs such as the liver and spleen. Subsequent examination revealed that in the majority of cases complete thrombosis had developed.

Coronary artery curettement

Experiments on dogs

MAY (1957) described experiments on the coronary arteries of dogs. A curette was prepared from a hollow tubular instrument and used for scraping the intima of the arteries In several cases the animals survived without any disability. Curettement was performed either by a transaortic route or by an approach through the terminal portion of the coronary arteries. The latter procedure was found to be quicker and more practicable Furthermore, it was associated with a higher rate of survival. The technique of retrograde curettement consisted in opening the chest and pericardium after injecting the pericardial sac with procaine solution. The apex of the heart was pulled upwards and a segment of the anterior descending coronary artery was isolated by means of sutures. A curette was

were found to be patent despite the trauma of the experiments. In a second series of experiments the aorta was exposed and pierced with a curette and stylet. After withdrawal of the stylet the curette was threaded into a coronary artery and the intima of the vessel ... Unfortunately, with the transaortic approach 2 of 4 dogs bled to death on

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PRECLINICAL CARCINOMA OF THE CERVIX UTERI

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INTRODUCTION

With advances in radiotherapy and radical surgery the 5-year survival figures of carcinoma of the cervix have improved slightly but to a disappointingly small degree. Way (1955) estimated that 4 per cent of cases of carcinomas of the cervix are curable by radiation and not by surgery, 9 per cent are curable by surgery only, 16 per cent are curable by either method and 71 per cent are incurable by either method. With the introduction of supervoltage, the 5-year survival figures can be expected to improve by 10 per cent but it is mainly Stage 2 and 3 cases who will benefit from this advance in radiotherapy (Blomfield, 1955). The development by the Grahams (Graham and Graham, 1955) of a cytological technique based on the sensitization and radiation response may indicate those patients who should be treated by radical surgery and select those who will respond satisfactorily to radiotherapy.

In New Zealand the over-all 5-year survival rate of carcinoma of the cervix is 42 per cent. Only slightly more than one-third of the clinical cases are diagnosed while still Stage 1 One-third of the cases admitted for treatment have already progressed to Stage 2, while the remainder are admitted as advanced cases. The New Zealand 5-year survival rate of Stage 1 cases is 70 per cent, for Stage 2 cases 41 per cent, for Stage 3 cases 11 per cent and Stage 4 cases 3 per cent

On the other hand, the 5-year survival rate for preclinical carcinoma is 100 per cent (Latour, Brown and Turnbull, 1957) Consequently, more can be achieved by early diagnosis than by all the known refinements in the treatment of clinical carcinoma Moreover, the treatment of preclinical carcinoma is not such a major undertaking as the management of clinical carcinoma.

DEFINITION

Preclinical carcinoma of the cervix embraces the earliest stages which produce neither symptoms nor signs On visual inspection the cervix appears benign and the carcinoma can be demonstrated only microscopically.

Stage 0 carcinoma of the cervix (carcinoma *in situ*, preinvasive carcinoma or intra-epithelial carcinoma) presents the features of carcinoma except that there is no invasion of the stroma and consequently no metastases have occurred. The basal cells of the epithelium extend right to the free edge and are irregular in size and shape with hyperchromatic nuclei. Mitoses are more common than in normal epithelium. These changes may extend into a cervical gland but there is no invasion through the basement membrane.

Stage 1 (*preclinical*) has the same features as Stage 0 except that invasion of the superficial layers of the stroma below the epithelium, though not extensive, has occurred. It can be differentiated from Stage 1 (clinical) by the fact that no *malignant* lesion can be detected by clinical examination and that invasion is not extensive on histological examination.

Blaikley and his colleagues (1958) have recommended the following classification of Stage 1 carcinoma of the cervix. Group 1A, borderline invasive and preclinical invasive carcinoma. Group 1B, clinically diagnosed carcinoma. Group 1C, a carcinomatous growth with a diameter of 5 centimetres or more.

NATURAL HISTORY

Carcinoma of the cervix commences at the junction of the squamous and columnar epithelium at about the level of the external os of the cervix. Initially it is localized to one small area but it gradually replaces adjacent normal epithelium and finally invades the underlying stroma This usually occurs first on the endocervical side of the squamocolumnar junction. The carcinoma frequently reaches the parametrium before it appears on the vaginal surface of the cervix (Gusberg, Fish and Wang, 1953).

DIAGNOSIS

The early stages of carcinoma are diagnosed by microscopic examination of tissue sections obtained because (1) tissue was removed during the surgical treatment of some other condition and was subjected to routine histological examination, or (2) biopsy was carried out as the result of a positive cytological report.

Cytology

Cells from the epithelium can be obtained for cytological examination by the following techniques·

Techniques

Cervical smear.—A cervical smear or surface biopsy is made by scraping the squamocolumnar junction with a flat narrow wooden spatula. A tongue depressor split lengthwise can be employed; the end of this is placed in the external os and by means of a rotary movement the surface cells are removed and smeared thickly on a microscope slide.

Vaginal smear.—This type of preparation is made by aspirating the secretion from the posterior fornix and smearing thickly on a microscope slide.

Endocervical smear.—A small probe covered with cotton-wool is inserted into

the lower end of the cervical canal and by a rotary movement part of the endocervical plug of mucus is transferred to a microscope slide.

Combined smear.—All three types of smear may be made on different areas of the one microscope slide.

Fixing and processing of smears

The slide is fixed in a mixture of 50 per cent surgical spirit and 50 per cent ether for at least half an hour and then allowed to dry in air The slides are then forwarded to the cytological laboratory for staining and examination. Specially trained technicians examine the stained smears and discard those containing only obviously normal cells. The balance of the smears are reported on by a pathologist who has had special training and experience in cytological work.

Reliability of smears

The cervical smear usually contains a liberal number of fairly well preserved malignant cells if an early carcinoma is present. A thinly spread smear or a considerable amount of blood may result in failure to transfer malignant cells to the slide. Advanced growths with extensive areas of necrosis may fail to give reliable smear preparations. Cells from adenocarcinoma of the body are rarely picked up in the cervical smear and adenocarcinomas of the cervix are also frequently missed. However, the cervical smear can be relied on to detect 80–90 per cent of early squamous carcinomas of the cervix (Gusberg, 1953)

Kulcsar (1950) found that vaginal smears will pick up malignant cells from about 60 per cent of adenocarcinomas of the body but it may miss 45 per cent of carcinomas of the cervix, although McLaren, Taylor and Attwood (1956) encountered only 4 false negative reports (13 per cent) in vaginal smears taken from 31 cases of adenocarcinoma.

Endocervical smears have a reliability of the same order as cervical smears (Nieburgs, 1956). However, cases missed by one technique can frequently be detected by the other

The ideal arrangement is to make all three types of smear on the one slide. This means a little extra work for the clinician but entails no extra work in staining and very little extra time in reporting.

A positive cytological report should always be confirmed by a cone biopsy from the squamocolumnar junction before making a final diagnosis of carcinoma or instituting treatment Multiple segments of the biopsy material have to be examined to be sure an area of invasion has not been overlooked

DIFFERENTIAL DIAGNOSIS

Basal cell hyperplasia

This is characterized by a basal cell layer which is thicker than normal but does not extend to the free surface Superficial layers of the epithelium show some degree of flattening and differentiation. The individual basal cells are more regular in size, shape and staining than is the case with Stage 0 carcinoma.

In some instances basal cell hyperplasia may be an early phase of Stage 0 carcinoma, particularly if there is any degree of cellular irregularity with hyperchromatic nuclei (Wheeler and Hertig, 1955), but it is usually classified and treated as benign However, follow-up examinations are warranted

Squamous metaplasia or epidermization

This may occasionally mimic the invasion of Stage 1 carcinoma at the same time showing hyperchromatosis and poor differentiation into surface squamae. However, the cells are regular in shape and size and cells ballooned with cervical mucus may be mixed up with this metaplastic epithelium.

INCIDENCE

The average age incidence of intra-epithelial carcinoma was 38 years in 201 cases studied by Wheeler and Hertig (1955) and 30–34 years in 393 cases collected by Erickson and his colleagues (1956). The average age of 529 clinical Stage 1 cases in Wheeler and Hertig's series was 50 years, while the average age of their Stage 4 cases was 52·5 years.

Petersen (1955) followed 84 cases of Stage 0 carcinoma of the cervix and concluded that the life history of this stage extended up to 15 years.

The number of cases of Stage 0 and early Stage 1 (preclinical) carcinoma of the cervix present in the population depends on:

Age

Nieburgs and his colleagues (1957) published the results of screening, by means of the endocervical smear, 16,604 white women in Floyd County, Georgia, United States of America. Stage 0 cases were detected at the rate of 2 per 1,000 below the age of 30 years, 4·5 per 1,000 between 30 and 40 years and 7 per 1,000 over the age of 40 years

Race

Erickson and his colleagues (1956), using the vaginal smear technique, attempt to screen all women over the age of 20 years in Shelby County, Tennessee, Unite States of America. On analysing the results of the first 108,136 women investigated 4·2 Stage 0 and 1·3 unsuspected (preclinical) Stage 1 cases of carcinoma were detected per 1,000 women tested.

A second vaginal smear was made on 32,728 of the women a year later. Three Stage 0 cases were detected per 1,000. Most of these were probably cases that had been missed by the initial test Half the cases found were in Negresses who constituted only one-third of the population surveyed.

Patients with gynaecological symptoms

In many centres, rather than screen all women in a certain age bracket, the policy has been to restrict the employment of smears to women attending a clinic where, for other reasons, a vaginal examination has been required. A very large proportion of the women attending a gynaecological clinic are over 40 years of age and this has a bearing on the number of positive smears obtained.

Anderson (1957), using the cervical smear technique in Edinburgh, obtained 98 surprise positive reports from the examination of 9,910 gynaecological patients, a rate of 9·9 per 1,000. Of 30,310 gynaecological patients without clinical evidence of carcinoma screened at the Mayo Clinic, 270 or 8·9 per 1,000 were shown to have preclinical carcinoma of the cervix Of these cases 10 per cent were preclinical Stage 1 cases (Dahlin and his colleagues, 1955).

Pregnant women

Carter and his colleagues (1952) screened 48,294 gynaecological patients and 7,500 obstetrical patients and found an incidence of 5 cases per 1,000 of Stage 0 cases of carcinoma of the cervix in both groups. There is no reason to expect a different incidence in the pregnant and non-pregnant state, provided the age incidence is taken into account.

New Zealand figures

Of New Zealand women 1·5 per cent develop carcinoma of the cervix after the age of 40 years. By this age, 0·15 per cent of New Zealand women have already developed cervical carcinoma.

The incidence of carcinoma of the body of the uterus in New Zealand is about half that of carcinoma of the cervix.

Auckland results

In Auckland, New Zealand, cervical smears have been prepared routinely on all gynaecological and obstetrical patients over the age of 30 years attending the out-patient department. The results obtained during the first 3 years of this screening programme, the gynaecological section of which was begun in November 1954, are given in the Table.

TABLE

Type of patient	*Number screened*	*Number of Stage 0 surprise positives*	*Number of invasive surprise positives*	*Number of surprise positives per 1,000 screened*
Gynaecological .	8,951	18	4	2 4
Obstetrical . .	668	1	1	3 0

During the same period cervical smears were prepared by specialists and general practitioners while carrying out vaginal examinations in their own consulting rooms These were posted to the cytological laboratory for processing.

Smears obtained in this way	10,842
Patients screened	10,166
Stage 0 surprise positives	28
Stage 1 surprise positives	15
Surprise positive rate per 1,000 screened ..	4·2

By screening 20,101 smears from 19,785 patients over the age of 30 years, 67 surprise positives have been obtained, 20 of these being cases of early invasive carcinoma and the remainder examples of intra-epithelial carcinoma. All these positive smears were confirmed by cone biopsy.

On the basis that only 42 per cent of clinically diagnosed cases of carcinoma of the cervix in New Zealand survive 5 years and that all cases of preclinical carcinoma, if left untreated, would become invasive, 40 lives have been saved by this cytological survey

The laboratory cost of detecting a surprise positive was approximately £100 and,

on the basis that only 42 per cent of clinically diagnosed cases survive five years, the cost of saving a life was £170.

TREATMENT

Biopsy only

At the Radium Centre, Copenhagen, the policy has been to carry out biopsy only on preclinical cases of carcinoma of the cervix in premenopausal women and to follow them regularly by means of smears and biopsy.

Petersen (1955) reported on the outcome in 84 cases of Stage 0 and 43 very ea preclinical Stage 1 cases treated in this way. By the end of the first year 21 per ce of the Stage 0 and 16 per cent of the border-line cases showed no evidence carcinoma. The condition had regressed or the biopsy procedure had removed a the malignant cells.

Of Stage 0 cases 3·6 per cent developed manifest cervical carcinoma by the end of the first year, 16·4 per cent by the end of 5 years, and 25 per cent by the end of 8 years. The corresponding figures for the border-line invasive cases were 4·7 per cent, 32·2 per cent and 33·3 per cent.

Of the cases that regressed and were found to be free of carcinoma in later years it is difficult to determine how many were cured by the biopsies taken at the time of the follow-up visits.

Amputation of the cervix or cone biopsy

In Stage 0 cases cone biopsy is probably adequate treatment provided the tissue removed is examined carefully histologically to make sure the abnormal epithelium does not extend to or across the line of incision. When this occurs amputation of the cervix is necessary.

This is the method of treatment advocated in the younger age groups where conservation of reproductive function is desirable. As the carcinomatous change may extend up the cervical canal in 64 per cent of cases (Gusberg and Moore, 1953) it is important to remove at least the lower centimetre of epithelium of the cervical canal.

Total hysterectomy

This is the method of treatment preferred at or after the menopause in patients who are good operative risks. Up to the age of 45 or 50 years some gynaecologists would conserve the ovaries.

TREATMENT OF THE PREGNANT PATIENT

Squamous metaplasia has been reported by Nesbitt and Hellman (1952) to occur in 60 per cent of pregnancies and basal cell hyperplasia in 10 per cent. Epperson and his colleagues (1951) and Nesbitt and Hellman (1952) described 12 cases of intra-epithelial carcinoma detected during pregnancy which reverted to normal without treatment except for diagnostic biopsy. On the other hand, Greene and his colleagues (1953) and Peckham and his colleagues (1954) followed 10 patients with preinvasive carcinoma during pregnancy and [illegible] sisted after delivery Slate, Martin and M[illegible]

Petersen (1955) studied 12 cases that had preinvasive carcinoma at the start of pregnancy. In 2 cases invasive carcinoma was diagnosed 3 and 4 months after the end of the pregnancies. A further 3 cases developed invasive carcinoma, 2 of these 1 year after delivery and the remaining case 2 years after the birth of her child.

In half the 12 cases studied pregnancy exhibited an accelerating effect evidenced by increased polymorphism and nuclear irregularity in the biopsy specimens. Two cases showed regression of these changes after interruption of the pregnancy.

Preclinical carcinoma diagnosed during pregnancy should be assessed in the same way as in the non-pregnant patient. However, in spite of the hormonal influences that operate during pregnancy it is not exposing the mother to any appreciable risk to restrict treatment during pregnancy to a superficial ring biopsy to eliminate an obviously invasive carcinoma and postpone further therapy until after the delivery of the child.

BIOLOGICAL AND BIOCHEMICAL CHARACTERISTICS

Tissue culture cells from cases of intra-epithelial carcinoma behave more like cells from cervical carcinoma than from normal cervical epithelium (Moore, 1952; Glatthaar, 1951)

Both invasive carcinoma and intra-epithelial carcinoma have a higher rate of anaerobic glycolysis than normal or inflammatory cervical epithelium (Limburg and Uhlmann, 1952).

An area of carcinoma *in situ* is frequently found at the edge of an invasive carcinoma. Cells from an area of normal cervical epithelium obtained from a patient who has intra-epithelial carcinoma in another area grow more readily in tissue culture than normal cervical epithelial cells from a woman who is entirely free from cervical carcinoma

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SURGICAL INDUCTION OF LABOUR

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HISTORICAL

Soranus of Ephesus (A.D 138) is known to have induced labour by rupture of the forewaters This method was used as early as 1690 in England, but according to Denman (1802) it was not generally advocated till 1756, when a conference of physicians was held in London to devise means of eliminating the frightful mortality that followed caesarean section

INCIDENCE

Excluding those centres where a significant number of surgical inductions have been carried out for social indications or reasons of convenience (Erving, 1952; Daichman and Pomerance, 1953, Hukill, 1955), the frequency with which labour has been induced by rupture of the membranes has varied from 4 per cent (Women's Hospital (Crown Street), Sydney, Australia, and Queen Charlotte's Hospital, London) and 7 per cent (Women's Hospital, Melbourne, Australia, and University College Hospital, London) to 10 per cent (Belfast and North Middlesex, London). The incidence at the National Women's Hospital, Auckland, between 1955 and 1957 was 17 per cent and in Lanark, Scotland, 18 per cent (Tennent and Black, 1954), while in Birmingham during 1950–52 it was as high as 20 per cent (Parker, 1957).

TECHNIQUE

Preliminary procedures

Prior to rupturing the membranes it has been customary to give the patient a dose of castor oil, an enema and a hot bath.

The use of castor oil is time honoured. Some believed that stimulation of intestinal peristalsis produced reflex uterine contractions However, it is very doubtful if this occurs, and, if it does, there is little evidence to indicate that it produces any significant effect.

The main function of both the castor oil and the enema is to empty the lower bowel and thus facilitate the entry of the presenting part into the pelvis. As the presenting part produces pressure on the lower segment and cervix, reflex secretion of endogenous pituitary oxytocin occurs (Harris and Pickles, 1953).

The bath contributes to the patient's comfort after the enema, but, ideally, immersion of the vaginal orifice in contaminated water should be avoided. A shower provided with a stainless steel stool and hand rail for support is a safer alternative to the traditional bath.

In the past, quinine and stilboestrol have been given in an endeavour to increase the irritability of the uterus. As long ago as 1880, Runge observed that following quinine administration to the mother, meconium was present in the amniotic fluid. Stilboestrol does not increase the sensitivity of the uterine muscle to pitocin and there is nothing to be gained by the use of female sex hormones as part of the technique of induction of labour.

Premedication

Anaesthesia carries a small risk and with the reduction of maternal mortality from other causes anaesthesia is becoming an important contributor to present-day maternal mortality. Consequently, general anaesthesia should be avoided in obstetrical practice if its employment is not really necessary. With adequate premedication, and care and gentleness on the part of the accoucheur, few women will require a general anaesthetic for surgical induction of labour.

Satisfactory premedication can be obtained with diamorphine $\frac{1}{6}$ grain, if this is available, or morphine $\frac{1}{4}$ grain combined with chlorpromazine 50 milligrams. Alternatively, pethidine 100 milligrams and chlorpromazine 50 milligrams can be used.

The pain experienced during the surgical induction of labour is produced by stretching the cervix. By avoiding as far as possible tension on, or stretching of, the cervix, very little pain will be felt by the patient. In some cases, where the internal os will admit the index finger only with difficulty, a little trilene breathed for a few minutes at an analgesic level will be all that is required to avoid distressing the patient.

Stripping the membranes

Following aseptic toilet of the vulva, preferably with chlorhexidine cream and with a liberal covering of the same preparation on the examining fingers, the index finger is passed through the cervical canal and the membranes stripped from the lower segment for a distance of 5–7 centimetres from the internal os.

The closed cervix

Very occasionally on vaginal examination the cervix is found to be long and closed and a finger cannot be passed through the internal os.

This difficulty can be overcome by giving a carefully supervised intravenous infusion of pitocin for a period of up to 48 hours (Faris and Kahlenberg, 1954; Mauzy and Donnelly, 1952; Parker and Roberts, 1954; Lennon, 1957), whereupon the cervix will usually be found to be taken up. Alternatively, with the patient under a general anaesthetic the cervix can be dilated with Hegar dilators.

If the indication for induction is not pressing, laminaria tents, adequately sterilized, can be employed to produce slow dilation of the cervix. However, if there is sufficient patency of the cervical canal to permit the introduction of a

laminaria tent, the internal os can be digitally dilated without great difficulty until it admits a finger.

Artificial rupture of membranes versus other techniques

Van Dongen (1956) found, before rupture of the membranes, a failure rate of 53 per cent with castor oil, enema, bath and 2 units of pitocin given half-hourly for 8 doses. When an intravenous pitocin infusion was used to replace intramuscular pitocin, the failure rate was reduced to 39 per cent. Rupture of the membranes alone failed to induce labour in only 10 per cent of his cases However, the cases with long and uneffaced cervices were given medical inductions, while surgical induction was limited to cases possessing a "ripe" cervix.

Gibson (1952) found that rupture of the membranes resulted in a shorter latent interval than occurred with the use of a Jacques bougie Evans (1954) recorded an induction-delivery interval of over 48 hours in 32 per cent of his cases who were induced by rupture of membranes alone, while 54 per cent of those induced with a rubber bougie had an induction-delivery interval in excess of 48 hours. Mackie (1944), who reviewed cases treated between 1938 and 1943, found that the induction-delivery interval was almost twice as great when the membranes were stripped and a rectal tube introduced between the membranes and the lower segment as when the forewaters were ruptured. The rectal tube technique was associated with a 2 5 per cent maternal mortality mainly from anaerobic infection, while none of the mothers induced by rupture of the membranes died of infection.

As rupture of the membranes is more effective than the employment of bougies, it has almost universally replaced this latter method The risk of infection being related to the induction-delivery interval, the more effective technique also carries a smaller risk of sepsis

King George V Hospital, Sydney, has recently been following the practice of daily digital stretching of the cervix and stripping of the membranes with delay of membrane rupture until the cervix is taken up and dilated to one or two fingers' breadth (Cunningham, 1954).

Forewater versus hindwater rupture

A forewater rupture can be readily carried out with a pair of packing forceps without a ratchet while a hindwater rupture is effected by the employment of the Drew–Smythe catheter (Smythe, 1931)

In carrying out a hindwater rupture, the tip of this catheter is passed along the index finger which has been used to strip the membranes. The tip of this finger, held just inside the internal os, is used as a fulcrum to keep the tip of the Drew–Smythe catheter in contact with the presenting part as it is gently passed into the uterus. This is effected by a movement of the wrist of the other hand and should occur without the use of any force. When the external end of the Drew–Smythe catheter lies on, or close to, the perineum the stilette is pushed home and by depressing the external end the point will puncture the hindwaters as the catheter is still pivoted on the tip of the index finger.

Considerable difference of opinion exists as to which of these two techniques is the more effective.

Gibson (1952) obtained the results shown in Table I and other series are recorded in Table II

Bellingham (1954) studied 106 primigravidae and 215 multiparae and found that in both groups forewater rupture was associated with an average induction-delivery interval of slightly less than half that obtained with hindwater rupture.

Thus, the available evidence suggests that forewater rupture may be slightly more effective than hindwater rupture, but the difference is small.

TABLE I

Method	*No. of cases*	*Ripe cervix (per cent)*	*Latent interval in excess of 24 hours (per cent)*
Forewater rupture . .	529	94	17
Hindwater rupture . .	202	82	39

TABLE II

Method	*No. of cases*	*Induction-delivery interval over 48 hours (per cent)*
Evans (1954)		
Forewater	155	28
Hindwater	153	38
Llewellyn-Jones (1955)		
Hindwater + intravenous pitocin required in 15 per cent of cases surgically induced .	410	7
Manly (1956)		
Forewater . . .	60	21
Hindwater . . .	393	21
Lennon (1957)		
Forewater . . .	987	22

RISKS OF SURGICAL INDUCTION

Cord prolapse

It has been suggested that there is a greater danger of cord prolapse with a non-engaged presenting part, especially if forewater rupture is carried out.

However, the average frequency of cord prolapse in 6,058 recently published cases of surgical induction was 0·5 per cent and there was no significant difference in incidence in those induced by forewater or hindwater rupture. Parker (1957) had an incidence of 1·3 per cent of prolapse of the cord in 718 cases of hindwater rupture compared with a 0·8 per cent cord prolapse rate in 3,093 booked cases not surgically induced.

streptomycin can thus be obtained in the amniotic fluid with absorption into the foetal and maternal circulations and the production of better sustained blood levels than with intramuscular injections. This is accomplished without inconvenience to the mother or the nursing staff.

Haemorrhage

Manly (1956), in attempting to carry out hindwater rupture in 440 cases with a Drew–Smythe catheter, encountered blood-stained fluid or blood in 32 (7·3 per cent). By performing a forewater rupture, all these cases were eventually delivered vaginally without maternal or foetal mortality.

Bleeding can be avoided by employing forewater rupture as the primary procedure.

Loss of liquor

Manly (1956) found no correlation between the quantity of liquor initially removed and the induction-delivery interval.

Intra-uterine death occurred in 25 per cent of Gibson's (1952) surgically induced cases where the latent interval exceeded 72 hours, and he suggested that this was related to an accentuation of placental insufficiency following loss of the liquor.

Judging by the low foetal wastage in large series of surgical inductions, including those performed for pre-eclampsia, the loss of the liquor cannot be a very important contributory factor towards intranatal death of the foetus.

Perinatal mortality due to induction

Evans' (1954) figure of 2 per cent foetal loss due to surgical induction is largely the result of his abnormally high incidence of prolapse of the cord. Manly (1956) considered that, of the 500 cases where labour was induced surgically, 6 (1·2 per cent) babies may have died as a result of the induction. In the 1,099 surgical inductions reported by Parker (1957) this procedure contributed to the loss of 12 babies (1·1 per cent); placental separation associated with hydramnios in 4, prolapse of the cord in 3, intra-uterine infection in 3, error in maturity estimation 1, and 1 impacted shoulder presentation.

Racker, Burgess and Manly (1953), using mainly the Drew–Smythe catheter to induce labour routinely at the expected time of delivery in otherwise normal cases, encountered 3 (1·5 per cent) stillbirths in 203 cases compared with a still-birth rate of 1 54 per cent in 1,229 normal cases going into labour spontaneously within 7 days of their expected date of delivery.

Maternal mortality

In recently published cases rupture of the membranes was not a prime cause of maternal death in any case. However, it may have been a contributing factor by increasing the risk of sepsis in 4 instances out of 3,922 cases of artificial rupture of the membranes—that is, a rate of 0·1 per cent.

EFFECTIVENESS OF SURGICAL INDUCTION

For induction-delivery interval, latency (that is, induction to start of labour) and length of labour, see Tables IV, V and VI respectively.

TABLE IV

Induction-delivery Interval

<table>
<tr><th rowspan="2">Author</th><th rowspan="2">No of cases</th><th colspan="4">Induction-delivery interval</th></tr>
<tr><th>0–24 hrs (per cent)</th><th>25–48 hrs (per cent)</th><th>49–72 hrs. (per cent)</th><th>Over 72 hrs (per cent)</th></tr>
<tr><td>Racker, Burgess and Manly (1953)</td><td>162</td><td>38</td><td>43</td><td colspan="2">19</td></tr>
<tr><td></td><td></td><td colspan="2">81</td><td colspan="2"></td></tr>
<tr><td>Lemmon (1948)</td><td>1,113</td><td>71</td><td>14</td><td>9</td><td>6</td></tr>
<tr><td></td><td></td><td colspan="2">85</td><td colspan="2">15</td></tr>
<tr><td>Manly (1956)</td><td>500</td><td>51</td><td>30</td><td>10</td><td>9</td></tr>
<tr><td></td><td></td><td colspan="2">81</td><td colspan="2">19</td></tr>
<tr><td>Evans (1954)</td><td>507</td><td colspan="2">68</td><td colspan="2">32</td></tr>
<tr><td>Lennon (1957)</td><td>987</td><td colspan="2">78</td><td colspan="2">22</td></tr>
<tr><td>Llewellyn-Jones (1955)</td><td>410</td><td>68</td><td>25</td><td colspan="2">7</td></tr>
<tr><td></td><td></td><td colspan="2">93</td><td colspan="2"></td></tr>
<tr><td>Auckland (1955–57)</td><td>709</td><td>62</td><td>24</td><td>9</td><td>5</td></tr>
<tr><td></td><td></td><td colspan="2">86</td><td colspan="2">14</td></tr>
</table>

TABLE V

Latency

<table>
<tr><th></th><th>No. of cases</th><th>0–24 hrs. (per cent)</th><th>25–72 hrs (per cent)</th><th>Over 72 hrs. (per cent)</th></tr>
<tr><td>Tennent and Black (1954)</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Primigravidae</td><td>726</td><td>75</td><td>16</td><td rowspan="2">9
12 } 10 5</td></tr>
<tr><td>Multiparae</td><td>859</td><td>73</td><td>15</td></tr>
<tr><td></td><td></td><td>0–24 hrs (per cent)</td><td>25–48 hrs. (per cent)</td><td>Over 48 hrs. (per cent)</td></tr>
<tr><td>Parker (1957)</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Primigravidae</td><td>428</td><td>61</td><td>20</td><td>19</td></tr>
<tr><td>Multiparae</td><td>577</td><td>56</td><td>19</td><td>25</td></tr>
</table>

TABLE VI

Length of Labour

	No of cases	0–24 *hrs (per cent)*	25–48 *hrs. (per cent)*	*Over 48 hrs (per cent)*
Tennent and Black (1954)				
Primigravidae	726	89	10	1
Multiparae	859	95	4	1

Parity

The above figures demonstrate that women having their first baby come into labour as readily as multiparae following surgical induction, but, due to their shorter labour, the induction-delivery interval is shorter with multiparae.

Maturity

Parker (1957) found that maturity had little influence on the latent period (from rupture of membranes to the start of labour). Evans (1954) made a similar observation with regard to the induction-delivery interval.

An analysis of 301 cases, induced at varying times after the thirty-fourth week for pre-eclampsia and essential hypertension at the Women's Hospital, Melbourne, during 1954, showed that maturity was without effect on the latency following forewater rupture.

State of the cervix

Guttmacher and Douglas (1931) stressed the importance of the condition of the cervix in relation to the success of surgical induction of labour, and Dieckmann and McCready (1947) considered an "unripe" cervix a contra-indication to induction of labour.

Manly (1956) found no difference in the induction-delivery interval of cases with soft (ripe) or hard (unripe) cervices. However, the greater the cervical dilatation at the time the membranes were ruptured, the shorter was the induction-delivery interval (Table VII).

TABLE VII

State of cervix	*No. of cases*	*Induction-delivery interval*			
		0–24 hrs (per cent)	*25–48 hrs. (per cent)*	*49–72 hrs (per cent)*	*Over 72 hrs (per cent)*
Closed	98	20	41	19	19
Dilated to 1 finger	240	49	33	10	8
Dilated to 2 fingers	130	77	20	8	4

Tennent and Black (1954) paid no regard to the condition of the cervix in carrying out 1,585 surgical inductions.

Efficiency of labour following artificial rupture of the membranes

Tennent and Black (1954) induced labour at 38 weeks for minor degrees of pelvic contraction in 53 primigravidae and 68 multiparae. Only 12 of these were delivered by caesarean section. Prolonged labour was infrequent, only 1 case lasting over 48 hours.

Failed induction

Most women who have had their membranes artificially ruptured will eventually go into labour. Tennent and Black (1954), who did not use pitocin, had 1 case out of 1,585 with an interval of 43 days after surgical induction before labour started. In this case neither mother nor baby suffered any upset. In 8 per cent the delay

following surgical induction before the onset of labour was between 3 and 7 days, and in 2 per cent between 7 and 14 days. In 4 cases (0·3 per cent) the delay was 14 days or over.

In view of the increased risk of sepsis with longer induction-delivery intervals and the possible harmful effect, especially in cases of placental insufficiency, of allowing all the liquor to drain away, an endeavour should be made to have the patient in labour by 48 hours and delivered within 72 hours One in 5 women will not be in labour within 48 hours, and 1 in 10 within 72 hours of surgical induction unless subjected to some form of uterine stimulation.

Manly (1956) tried giving intramuscular pitocin 2·5 units half-hourly for 6 doses to 53 cases who had not come into labour within 48 hours. This treatment resulted in only 50 per cent of the patients going into labour.

Parker (1957) frequently gave a medical induction if labour had not commenced within 24 hours of rupture of the membranes

Llewellyn-Jones (1955) induced 410 patients by rupture of the hindwaters and found that 68 per cent were delivered within 24 hours, and 93 per cent within 48 hours. Intravenous pitocin was used in 19 cases (5 per cent) during the first 24 hours following membrane rupture, and in 41 (10 per cent) of the cases 24 hours after high puncture of the membranes

Pitocin given by continuous intravenous infusion is the technique of choice in reducing the induction-delivery interval. If the intravenous pitocin is started immediately following surgical induction, many women will be given unnecessary pitocin drips. By waiting approximately 24 hours, two-thirds to three-quarters of the cases induced will be in labour and attention can then be concentrated on running pitocin drips on the residue.

Intravenous pitocin infusion

With the one-third of the primiparae and one-fifth of the multiparae undelivered by the end of 24 hours, or with severe pre-eclamptics whose delivery is urgent, a pitocin drip as well as rupture of the membranes is required to induce labour.

Intravenous infusion of pitocin is much more reliable than intramuscular pitocin since much of the intramuscular pitocin is destroyed before it can be absorbed. Moreover, with the intravenous technique the sensitivity of each individual patient is first determined, and as this varies within wide limits the final rate of administration is adjusted accordingly

Method of administration.—A bottle of 5 per cent glucose in water is set up with a standard intravenous giving set and the needle inserted into a vein, preferably on the forearm and away from flexures To a second litre bottle of 5 per cent glucose in water, 5 units (0 5 millilitre) of pitocin are added The air is expelled from the giving set attached to this bottle and the drip rate adjusted to 10 drops per minute Then, and only then, is the needle of this second set inserted into the rubber tubing of the first set close to where it enters the vein The response to this rate of pitocin administration is assessed by placing a hand on the fundus of the uterus [illegible]

the membranes and during the administration of the intravenous pitocin. Except

in sensitive individuals little response will be elicited by 10 drops per minute, therefore the rate is increased to 15 drops a minute and, provided prolonged or frequent contractions are not produced, the rate is further increased to 20 and then 25 drops a minute. If a length of polyethylene tubing has been introduced into the amniotic cavity at the time of rupture of the membranes and a manometer has been connected to it by a three-way tap, the frequency and duration of the uterine contractions can conveniently and accurately be gauged by watching the manometer. Some obstetric units have pen-writing manometers which draw a continuous record of the uterine contractions on a moving strip of paper.

The pitocin drip rate is gradually increased until satisfactory uterine activity is produced. The case should be seen at 2-hourly or 4-hourly intervals by the doctor, while at other times a reliable sister should be in constant attendance on the patient. Every 10 or 15 minutes she should record the foetal heart rate and the frequency and duration of the uterine contractions and check the drip to ensure that there has been no marked alteration in rate. If there is slowing of the foetal heart rate or frequent or prolonged contractions, she should be instructed to turn off the pitocin immediately and then notify the doctor.

In some cases the pitocin can be discontinued when labour is established, but in many cases it has to be continued throughout the labour, and it is preferable to continue administration into the third stage. Ideally, the pitocin should be stopped only after the placenta has been delivered and ergometrine has been given. Failure of intravenous pitocin to induce labour in multiparae is very rare, but of primiparae who require a pitocin drip 2 per cent (mainly postmature cases) may fail to come into labour. If these are allowed to start labour spontaneously they will probably manifest themselves as cases of incoordinate uterine activity and in any case will require delivery by caesarean section

Intramuscular pitocin following rupture of the membranes

The main disadvantage of the intravenous pitocin is that the technique is time consuming. If, for this reason, the administration of intramuscular pitocin is left to the nursing staff, they should be instructed to use a tuberculin syringe, to measure the dose accurately and take precautions to avoid the accidental intravenous injection of this powerful oxytocic. The response to an initial dose of 2·5 units (0·25 millilitre) intramuscularly should be noted and the foetal heart rate checked frequently The effect of the first dose is usually to augment the painless Braxton Hicks contractions, which should be assessed by placing a hand on the fundus for 10 minutes, 5 minutes after the administration of the first dose of pitocin. If the contractions are not prolonged for more than 2 minutes and do not occur more frequently than once every 3 minutes, it is usually safe to repeat the pitocin at hourly intervals as this is the duration of action of an intramuscular injection of 0·25 millilitre of pitocin If these precautions are observed it is safe to continue administration until labour is well established. Limiting the number of injections to 5 and suspending administration as soon as the contractions become painful will increase the failure rate.

Dangers of pitocin

In the use of pitocin with primiparae the main danger is the stimulation of prolonged contractions, especially following the initial administration. These

prolonged contractions embarrass placental circulation and produce foetal distress. In multiparae there is a danger of rupturing the uterus if excessive uterine activity is produced by uncontrolled injections of pitocin.

Synthetic pitocin (pituitary oxytocin) free of pitressin (vasopressin) is now available and is the best preparation for clinical use.

Caesarean section following surgical induction

The incidence of caesarean section for an excessive latent period following surgical induction has varied from 0·5 per cent (Tennent and Black, 1954) and 2 per cent (Manly, 1956) to 3 per cent (Parker, 1957).

The low incidence of caesarean section for failed surgical induction in the series reported by Tennent and Black (1954) was due to their conservative approach and their willingness to allow, if necessary, a long latent interval Of 7 caesarean sections following a latent interval over 72 hours, only 1 developed a temperature of over 100°F for 2 days The majority of these cases had been given antibiotics prophylactically.

A 0·5 per cent incidence of caesarean section in the surgically induced cases of Llewellyn-Jones (1955) was associated with the use of intravenous pitocin in the management of 15 per cent of his patients

In women induced by forewater rupture Lennon (1957) found that the caesarean section rate was in inverse proportion to the number of pitocin drips carried out.

INDICATIONS

Pre-eclampsia and essential hypertension

Pre-eclampsia and hypertension have been the commonest indications for surgical induction of labour, although in some recently reported series postmaturity occupies first place by a small margin The relative frequency with which "toxaemia" has been the indication for surgical induction has varied from 40 per cent (Tennent and Black, 1954) to 76 per cent (Gibson, 1952)

Brown, McClure and Veall (1953) observed the speed with which radioactive saline solution injected into the placenta was washed away and by this means demonstrated a reduced placental blood flow in both pre-eclampsia and essential hypertension Morris (1957) made similar observations with regard to the blood flow in the wall of the uterus Carey and Liley emphasized that the risk of the

of gestation, there is a significant risk of the baby dying of prematurity. Consequently, in the management of cases developing hypertension and albuminuria during the twenty-eighth to thirty-fourth week, the optimum time for induction is the period of gestation at which the risk of losing the baby from prematurity is less than the risk of the foetus dying *in utero* Carey and Liley have evolved a formula for determining the best time for surgical induction in any individual case of albuminuria and hypertension. Cases of hypertension uncomplicated by oedema or albuminuria carry a better prognosis for the foetus and consequently

surgical induction can usually be delayed till the thirty-sixth to thirty-eighth week. Cases of even mild "toxaemia" or those with signs of only short duration should not be allowed to go past the calculated data of delivery; in fact, after the thirty-eighth week of gestation any case of pre-eclampsia should be induced surgically after 2 or 3 days' conservative treatment in hospital

Eclampsia

The treatment of eclampsia is essentially similar to that of severe pre-eclampsia. Prior to the thirty-third week an attempt should be made to control the maternal signs by hypotensive drugs, sedation and salt elimination. Some cases will settle down without recurrence of fits and can be carried to the thirty-third week of gestation In others, intra-uterine death will occur followed by a marked improvement in the maternal condition. Labour can then be induced with minimal risk to the mother. In a very few cases failure to control the maternal signs will be the indication for induction.

If the pregnancy has already advanced beyond the thirty-fourth week the mother should be heavily sedated with intramuscular sodium phenobarbitone, and the blood pressure lowered to nearly normal levels by protoveratrine given subcutaneously or by intravenous drip When the maternal condition has been controlled, the membranes should be ruptured Surgical induction of labour rather than caesarean section is the best method of emptying the uterus in eclampsia.

Chronic nephritis

The same principles as outlined under pre-eclampsia and essential hypertension apply to this disorder. Inulin clearance is the best measure of glomerular filtration rate, and para-aminohippuric acid (PAH) clearance the most reliable index of renal plasma flow. These renal function tests can be carried out in most well-equipped hospitals. If done at monthly intervals, they will indicate any deterioration in renal function.

Postmaturity

Walker and Turnbull (1953) and Walker (1954) published evidence which suggested that, as a pregnancy continued past the due date, the placental reserve declined and there was a reduction in the oxygen saturation of the blood which passed from the placenta to the foetus. By the forty-third week this reached a critical level and gave rise to foetal distress

MacKay (1957) has, in general, confirmed Walker's work, although she found that the reduction in the oxygen saturation of cord blood in babies born after the estimated date of delivery was not as great as Walker's observations had suggested Her findings in pre-eclampsia were also similar to Walker's and indicated a reduction below the normal oxygen saturation of cord blood with progression of this change as the pregnancy continued past the due date.

Browne (1955) measured placental blood flow in postmature pregnancies and found it to be within normal limits

The work of Bancroft-Livingston and Neill (1957) has led to conclusions quite opposed to those of Walker The Belfast workers believed, on the basis of quite

extensive investigations, that postmaturity was not associated with the risk of f death from anoxia.

In spite of this conflicting evidence there is fairly general agreement tha stillbirth rate rises significantly after the forty-second week of gestation.

Clayton (1953) and Macafee and Bancroft-Livingston (1958) were of the op that this resulted from the association of postmaturity with a higher inciden mechanical difficulties during labour due to the more frequent occurrence of l babies and inefficient uterine action.

About 8 per cent of women will not have started in labour by the forty-se week of pregnancy and only half of these will deliver during the following Consequently, the routine induction of labour by surgical means at the end c forty-second week of pregnancy will result in a very high interference rate. E precautions are taken to allow for variations in the menstrual cycle and only with reliable dates are considered, the question arises as to whether the ris routine induction do not approach the risks to the foetus from postmaturity.

Induction for postmaturity is really justifiable only if some degree of sele of cases is practised. Cases with mild "toxaemia" should not be allowed to be postmature, but primigravidae who have a very adequate pelvis and are normal in every other way, and multiparae with a good obstetrical history, sl be allowed to go into labour spontaneously irrespective of the period of gest

Tennent and Black (1954) induced their cases when the pregnancy had cont for one week past the estimated date of delivery. This indication accounte 40 per cent of their surgical inductions, and was associated with a correcte congenital abnormalities) foetal mortality of 0 9 per cent.

In Parker's (1957) series of surgical inductions, postmaturity was the indic for this procedure in 19 per cent. In Auckland during 1955–57 postma accounted for one-third of the surgical inductions performed.

Contracted pelvis

The risks of postmaturity are largely due to minor degrees of dispropo frequently because of a large baby. Where there is a history of large babies c pelvis is known to be border-line, it would appear logical to advance the ti induction to as early as the thirty-eighth week, depending on the size of the However, clinically it is possible to obtain only a rough impression of the size and radiologists, except for those who have mastered Hartley's tech (Hartley and Fisher, 1953), are frequently no more accurate in their estim than the clinicians Tennent and Black (1954) induced cases with minor degr pelvic contraction at the thirty-eighth week, provided no obvious dispropc was present, and then managed the cases as trials of labour. They handl primigravidae and 68 multiparae in this way. One infant died of prematurit there was 1 unexplained stillbirth. The induction failure rate was similar t of their entire series and prolonged labour was infrequent, only 1 case lasting 48 hours The caesarean section rate was 9·9 per cent.

Tennent and Black (1954) also induced labour in 76 cases where on cl assessment a large baby was thought to be present. The only infant lost wa who died from pneumonia. No baby weighed less than 6 pounds and o weighed under 7 pounds. In only 1 case did labour last more than 48 hours.

Breech presentation

Breech delivery is associated with the lowest perinatal mortality when the baby weighs 6·5–7 pounds. In order to obtain these favourable conditions, Mair (1953) carried out surgical induction in cases of failed external version when the foetus was considered to be 6·5 pounds in weight. It is usually the breech with extended legs in a primigravida that cannot be converted into a vertex by external version, and this is the type of case which is particularly suitable for induction, provided there is radiological evidence that the pelvis is adequate.

Diabetes mellitus

Because of the association of large babies with both diabetes mellitus and prediabetes in the mother, and the high risk of intra-uterine death from placental insufficiency during the last month of pregnancy, it is now accepted practice to deliver diabetics and prediabetics between the thirty-fifth and thirty-seventh weeks (Peel, 1955).

Diabetics and prediabetics who have had a previous vaginal delivery have been managed by surgical induction, while primigravidae have usually been subjected to elective caesarean section.

Pedersen and Brandstrup (1956) compared the foetal loss of those patients who had been under strict medical control throughout the second half of pregnancy with those who were not so well supervised. He aimed at delivery about the thirty-sixth week and only 18 per cent of his patients were delivered by caesarean section. In the strictly supervised group the foetal loss was only 10 per cent. This suggests that, with the introduction of the pitocin drip, even primiparae should have their membranes ruptured, and caesarean section be reserved for those who do not go into labour readily or where progress during labour is not satisfactory.

Bad obstetrical history

When a woman gives a history of unexplained stillbirths, it is frequently desirable to consider induction of labour about the thirty-sixth to thirty-eighth week, depending on the stage of the earlier pregnancies at which the stillbirths occurred.

Placenta praevia

Minor degrees of placenta praevia include those cases in which it is possible for the presenting part during labour to pass the placenta without separating it. Such cases usually include first and anterior second degree cases, but where the pelvis is large it may include all types of lateral placenta praevia. Such cases are diagnosed by examination under anaesthesia in the theatre, usually about the thirty-eighth week, unless persistent bleeding has indicated the desirability of interference nearer the thirty-sixth week.

Rupture of the membranes, as well as initiating labour, reduces the risk of placental separation during uterine contractions. Major degrees of placenta praevia should be delivered by lower segment caesarean section.

Accidental haemorrhage

In the severe concealed or concealed and revealed types, the foetus is usually dead. The most urgent aspect of treatment is resuscitation by blood transfusion

The association of afibrinogenaemia must always be kept in mind When the blood pressure has been restored to near normal levels the membranes should be ruptured and labour usually starts with little delay.

Severe cases with an audible foetal heart are usually subjected to caesarean section in the hope of saving the baby. Mild cases with a live foetus are handled in the same way as patients with pre-eclampsia.

Hydramnios

If after the thirty-sixth week the degree of hydramnios is sufficient to produce acute maternal discomfort, it is permissible to drain off some of the excess fluid by means of a large lumbar puncture needle passed through the anterior abdominal wall This procedure often has to be repeated every 2 or 3 days and usually precipitates the onset of labour.

Foetal abnormality

Where there is x-ray evidence of a foetal abnormality incompatible with life, such as anencephaly, labour should be induced as soon as the diagnosis has been made. Rupture of the membranes followed by an intravenous pitocin drip is the method of choice

Intra-uterine death

Diagnosis is based on failure to hear the foetal heart, and loss of foetal movements should be confirmed by x-ray evidence Intra-arterial gas can usually be demonstrated a few hours after death, and after 2 weeks Spalding's sign will become positive Induction of labour by means of a pitocin drip shortly after intra-uterine death will reduce the risk of afibrinogenaemia which occasionally occurs when a dead foetus has been retained *in utero* for over 3 weeks

Because of the risk of anaerobic infection it is preferable to try the effect of a pitocin drip without rupture of the membranes. If the patient fails to come into labour a forewater rupture can be carried out without an extensive stripping of the membranes, but under these circumstances large doses of penicillin and streptomycin should be given prophylactically.

Unstable lie near term

This is a not uncommon complication of multiparity. It carries the risk of a shoulder presentation with prolapse of the cord when the membranes rupture spontaneously.

It is as well to admit these cases to hospital about the thirty-ninth week, and near term carry out an external version and rupture of the membranes while the vertex is held over the brim. Even if the hindwaters are initially ruptured, this should be followed by a forewater rupture and a pitocin drip started without delay. There is often a tendency for the head to swing back into one iliac fossa unless the mobility of the foetus is reduced by stimulating uterine activity and encouraging contraction and retraction of the uterine muscle

Rhesus sensitization

When a mother has developed anti-D antibodies and her husband is homozygous for D, all her subsequent children will be affected by haemolytic disease. However,

with successive pregnancies the babies do not become progressively more severely affected, but in 3 out of 4 cases subsequent babies will be affected to approximately the same degree as the preceding one (Walker and Murray, 1956). When children have been only mildly affected the subsequent pregnancy can be allowed to proceed to term, but where there has been one previous stillbirth due to haemolytic disease the risk of intra-uterine death is high, and surgical induction about the thirty-fifth week followed by multiple exchange transfusions will give the best foetal salvage (Walker, Murray and Russell, 1957). A further guide to the need for induction can be obtained by the examination of a specimen of amniotic fluid obtained by passing a lumbar puncture needle through the anterior abdominal wall into the uterus. When there have been two previous stillbirths, induction at the thirty-second to thirty-third week should be considered.

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ABSTRACTS RELATING TO GYNAECOLOGY AND OBSTETRICS

PRECLINICAL CARCINOMA OF THE CERVIX UTERI

Early diagnosis and treatment

ANDERSON (1957) discussed the diagnosis and treatment of early cancer of the cervix. During the past 15 years a type of cancer has been found confined to the squamous epithelium of the external os and not yet infiltrating the connective tissue proper. Known

valuable in confirming negative clinical evidence. The significance of positive smears is closely associated with the size of the biopsy, hundreds of sections sometimes being necessary before malignancy can definitely be demonstrated The biopsy should come from the whole extent of the junctional epithelium at the external os, the site of election for early malignancy The smaller and less visible the lesions, therefore, the larger must be the biopsy By means of cervical smears 98 early superficial cancers were discovered among 9,900 patients, none had been suspected. One-third were invasive growths.

must be followed by the examination of cervical smears The cervical smear, then, offers a simple method of detecting cancer at an earlier stage, with a better prognosis and simpler treatment than hitherto

Value of routine cervical smears in pregnant women

avoiding biopsies where possible during pregnancy, an attempt was made to ascertain whether abnormal smears regressed to normal after delivery and, in correlation, whether the underlying abnormal tissue regressed to normal as has been reported in the literature, biopsies were taken from all patients who had clinical evidence of carcinoma or who had Class V smears suggesting invasive carcinoma. The results showed 45 abnormal smears, classified as follows: Class III (equivocal) 22; Class IV (probable carcinoma, usually carcinoma *in situ*) 14; and Class V (definite evidence of carcinoma *in situ* or of invasive carcinoma) 9. Of the Class III group, 7 became cytologically negative post partum and tissue study was not done: in 6 cases the post-partum diagnoses were atypical hyperplasia in 1, premalignant dysplasia in 3, and pre-invasive carcinoma in 2; 9 were lost to follow-up; in Class IV there were 4 cases of premalignant dysplasia, 7 of pre-invasive carcinoma, and 1 of the invasive carcinoma, 2 were lost to follow-up; of the Class V group, 3 had premalignant dysplasia (border-line lesions), 4 had pre-invasive carcinoma, and 2 had invasive carcinoma. An analysis of the data indicates that carcinoma *in situ* is as prevalent in pregnant as in non-pregnant women when equal numbers and various related factors are considered The study demonstrates that most abnormal epithelial hyperplasia occurring during pregnancy are not the result of pregnancy, these lesions remain with the host unless destroyed by biopsy or cautery, so no residual lesion is found on later examination.

Routine cytological screening

LATOUR, BROWN and TURNBULL (1957) discussed preclinical carcinoma of the cervix uteri. On the basis of an average annual total of 8,000 routine cytological screenings, the authors find approximately half of all their cervical cancers in the preclinical group, and they consider that if the number of cytological examinations could be doubled, the number of preclinical cancers of the cervix would rise proportionately. In the period 1947–55 there were 154 cases of preclinical cancer diagnosed by ring biopsy, with endocervical curettage and step-sectioning of serial blocks of the biopsy; these were the result of cytological screening of clinically negative cervices; 57 of these cases were diagnosed as carcinoma *in situ*, and 97 as "early invasive", it is noteworthy that since the introduction of these methods of diagnosis there has been a great increase in detection of preclinical cancers without a proportionate increase in the number of cases screened; in other words, many cases had escaped detection and were classified as cytological false positives by the usual punch biopsy. An increased bleeding tendency was noted in 14 of the cases of carcinoma *in situ*, and in 38 of the early invasive group; the authors feel that this tendency in the early invasive group occupies an intermediate place between the bleeding in carcinoma *in situ* and in clinical cancer and may indicate that this is a separate intermediate group. A review of the results of treatment of preclinical cancer indicates that carcinoma *in situ* may be safely and successfully observed only after the minimal treatment incidental to ring biopsy or conization plus endocervical curettage: conservative treatment is frequently rewarded by subsequent pregnancies, it appears that the dangers of overtreatment are more serious than the theoretical hazards of conservative therapy; both carcinoma *in situ* and early invasive carcinoma may be adequately treated by total hysterectomy with removal of the vaginal cuff and preservation of the ovaries. The segregation of early invasive cases in a separate category, suggested by the abnormal bleeding tendency, is further supported by the intermediate position of the age incidence and by a high rate of survival.

CLINICAL CARCINOMA OF THE CERVIX UTERI

Radiotherapy

Dose distribution and results

GUTTMANN (1957) discussed dose distribution and results in carcinoma of the cervix, comparing conventional high-voltage therapy including vaginal cone with super-voltage therapy. This study includes 393 unselected patients with histologically proved cervical carcinoma. They are divided into 3 groups according to the method of treatment employed.

receiving high voltage instead of low voltage cone treatment. Stage 4 results were poor

consisting of 40 patients, was treated by a combination of intracavitary radium and

Late complications occurred only once. The dosage with conventional therapy was

patient. Complications also appear to be fewer.

Prognostic value of end-of-treatment biopsies

FRICKE and DOCKERTY (1957) reviewed the prognostic value of end-of-treatment biopsies in treatment of cancer of the cervix Radioresistance to cancer is well known and constitutes a serious problem in treatment. Its earliest possible discovery is therefore important In this respect the Grahams have done promising work in radiation changes in vaginal cells during treatment. The other obvious method of detection is

securing a piece of tissue deep enough for representative section.

SURGICAL INDUCTION OF LABOUR

Uterine action

Physiological and clinical aspects

infusions. At the same time it is possible to estimate the pressure of the presenting part upon the cervix. If the pressure is not rhythmical the cause must be ascertained and an attempt must be made to remedy the defect. Although these measurements are desirable it is important to carry out a vaginal examination during contraction of the uterus. The manoeuvre is of value in detecting the degree of motility of the head and the concurrent rise in head-to-cervix pressure. Contractions may be induced by digital stimulation of the cervix, by fundal palpation and by intravenous injections of oxytocin. As a result of their study of the hydrostatics of labour Nixon and Smyth recommend the use of oxytocic drugs for controlling the intra-amniotic pressure. If the membranes are preserved intact

[illegible]

inertia due to weak and infrequent contractions. The infusions should consist of 5 units of oxytocin in 1 litre of dextrose, 5 per cent. The duration and drip rate of the infusions depend upon the nature of the contractions and the state of the cervix. Caesarean section may be required if oxytocin treatment and other medical measures fail to bring about a favourable effect.

Perinatal death

Foetal exsanguination

MITCHELL, ANDERSON and RUSSELL (1957) reviewed perinatal death from foetal exsanguination. Main consideration is given to foetal blood loss during vaginal delivery. Nine such cases in which 7 infants died are reported. In 3 cases blood was lost from ruptured vasa praevia; in 3 the ruptured vessels lay at a distance from the cervical os and were associated with a velamentous insertion of the cord or a succenturiate lobe of the placenta; in 1 the cause was undetermined. The most unusual case was one in which a large foetal [illegible] of labour.

[illegible]

in the placenta may be dam [illegible]
1955) reported upon the circumstances, frequency and [illegible]
anterior placenta. Since the adoption of their routine to eliminate this risk, no caesarean infant has died from foetal exsanguination. Its occurrence, however, from other causes, as in the cases reported, emphasizes the need for a test

CAESAREAN SECTION

Oxygenation of the foetus

HENDERSON, MOSHER and BITTRICH (1957) presented further oxygen studies of the cord blood of caesarean-born infants. Perfect initiation of respiration involves a normal

[illegible]

aspirated and swallowed. It is essential, therefore, to empty the stomach and aspirate the trachea at birth.

Rupture of the uterine scar

[illegible]

With the foetus still *in utero* the foetal parts can be palpated across the tear. Whereas 17 cases of ruptured classical scar have been recorded in 762 pregnancies, 8 cases of ruptured lower-segment scar have been recorded in 1,530 pregnancies The former complication led to the death of 5 of 100 mothers and a foetal mortality of 73 per cent, but with the latter complication there was no maternal mortality in 55 cases and the foetal mortality was 12 5 per cent. Evidently the lower-segment operation is to be preferred.

Foetal distress

DUMOULIN and MARTIN (1957) analysed the records concerning caesarean section which was performed for foetal distress associated with 97 primigravid and 33 multiparous patients Hypertension was found to be an important factor in the aetiology of the foetal condition. Caesarean section was carried out because the cervix was not sufficiently [illegible]

[illegible] and meconium abnormalities were present Maternal deaths occurred in 9 primigravid patients and 1 multiparous patient; hence the authors conclude that a more conservative

attitude should be adopted as regards carrying out caesarean section in multigravidae, especially when full dilatation of the cervix is imminent and an early termination of the first stage appears probable. It is believed that foetal distress is not a serious problem in prematurity. Surgical induction is indicated when patients with hypertension become postmature, but the manoeuvre should not be employed in all women at term. Oxygen therapy should be used in the management of foetal distress irrespective of the need for caesarean section.

GENERAL OBSTETRICS

Inevitable miscarriage

Suture of the cervix uteri

McDonald (1957) reported on 70 cases in which ligation of the cervix uteri was performed in order to prevent cervical incompetence and miscarriage. The surgical technique consisted in the insertion of a purse-string silk suture round the exo-cervix at the level of the internal os. The stitch was removed either at the thirty-eighth week or as soon as labour was established. Owing to the vascularity of the uterus it was possible to perform ligation without producing ischaemia of the cervix. In 69 cases belonging to the series there was a history of a previous miscarriage which had occurred at approximately the same time during pregnancy. After rupture of the membranes labour had usually been of short duration and relatively painless. Many patients gave a history of either cauterization or operative dilatation of the cervix. Ligation was most effective when it was performed at 20–24 weeks of gestation. No success was achieved when ligation was employed prior to the twentieth week. Although childbirth was usually premature, 33 mothers gave birth to live infants. Sixteen mothers had their pregnancies extended for a few weeks, but the foetus failed to survive. In the successful cases the suture held for more than 5 weeks. The presence of cervical incompetence was suspected when the patient complained of a vaginal discharge and discomfort in the lower part of the abdomen. On 3 occasions a mass in the vagina was found to be caused by the protruding bag of membranes. The diagnosis was confirmed by means of speculum examinations.

Post-partum oxytocics

Clinical evaluation

A comparative clinical evaluation of post-partum oxytocics was presented by Friedman (1957). A study was made of 1,221 patients who were divided into 5 groups as follows: (1) a control group who received no medication post-partum except as indicated; (2) a group who received oxytocin, 10 units intramuscularly; (3) those who received ergonovine maleate 0·2 milligram intramuscularly or intravenously; (4) those who were given methylergonovine tartrate 0·2 milligram intramuscularly or intravenously; and (5) a group who received dihydroergotamine methanesulphonate 1·0 milligram intramuscularly after delivery of the placenta. A record was made of blood pressure before and during pregnancy and labour, duration of labour, sedation and anaesthesia, estimated blood loss, and occurrence and degree of nausea and vomiting; haemoglobin levels before and after delivery were determined, the responsiveness of the uterus to the medication was noted, and atony reported, after excluding patients in whom adequate observations were not obtained, 894 cases remained. In order to ascertain whether the 5 groups were comparable so that only the single factor of the oxytocic used might explain any differences found, the cases were examined with regard to such factors as age, parity, gestational age, and precipitate and prolonged labour. The results indicated that oxytocin, ergonovine and methylergonovine were all equally effective in combating atony and preventing or controlling haemorrhage, the control group demonstrated that proper management of the fourth stage of labour did not necessitate routine use of an oxytocic; dihydroergotamine alone was clinically ineffective, giving evidence of actually inducing relaxation of the uterus. There

were remarkably few side-effects with the use of oxytocin; ergonovine and methylergonovine exhibited emetic and vasopressor effects. The author considers that oxytocin should be used for routine prophylaxis or therapy as a fourth-stage oxytocic.

Effective uterine blood flow during labour

Effective uterine blood flow during labour was discussed by WRIGHT and his colleagues (1958). Observations of uterine blood flow were made on 20 women during the early first stage of labour, and 26 in the late first stage; the flow was also measured in 3 of these women after foetal distress had appeared The method used for measurement was based on the Kety tissue clearance technique In the early first stage group all but 3 showed

which were likely to impair blood flow in the uterine wall. In the 3 cases in which foetal

when contractions are frequent, in normal confinements there is sufficient blood flow to ensure that during the hyperaemic phase the foetus is sufficiently oxygenated; in some instances, however, even the slight reduction in oxygenation caused by normal labour contractions may be dangerous when there are additional adverse factors such as prolonged pregnancy or placental infarction The authors have found that there is little danger to the foetus in pre-eclampsia unless the uterine clearance is prolonged beyond 12 minutes; there appears to be a critical level of uterine blood flow below which the chances of intra-uterine death are much increased.

Local analgesia and Kielland's forceps

SCOTT and GADD (1957) reviewed local analgesia and Kielland's forceps Forceps

foetal trunk by rotation of the head with Kielland's forceps under local analgesia. In 14 cases, all persistent posterior or transverse positions, rotation of the head and trunk were easily achieved without abdominal manipulation or traction. Gentleness, accuracy

anaesthesia While the foregoing policy was devised to reduce maternal anaesthetic risk,

it also benefited the foetus. The most important factor was probably the use of local analgesia, and a contributing factor the replacement of manual rotation by rotation with Kielland's forceps.

Traumatic maternal birth palsy

BROWN and McDOUGALL (1957) were of the opinion that, in cases of cephalopelvic disproportion, the foetal head may exert direct pressure on the lumbosacral cord during labour. As a result, neurological disturbances may occur in one lower limb. Occasionally both lower limbs are affected. The condition may develop in successive childbirths.

pression of the tube was effected by introducing a flexed foetal skull into the pelvis. It is

recovery may not ensue until a period of 1 year has elapsed. A case is recorded in which the patient suffered from permanent paralysis of the extensor tendon of the great toe and

aware of the symptoms during labour, but in most cases the weakness of the leg and foot became more obvious when household duties were resumed. Treatment consisted in the use of electrical stimulation, massage, graduated movements and exercises. Some patients

pain develops in the area of distribution of the lumbosacral cord during labour.

Mitral valvotomy during pregnancy

MARSHALL and PANTRIDGE (1957) discussed mitral valvotomy during pregnancy.

The majority, despite medical care, had rapidly deteriorated between the sixth and thirty-sixth weeks of gestation. In every case the clinical signs and symptoms indicated pure mitral stenosis with severe pulmonary congestion, but in none was there evidence of aortic valve disease or mitral incompetence. Crepitations were general; pleural transudates were detected in a few cases. Electrocardiography showed unequivocal evidence of right

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hours. Post-operative complications were few and unrelated to pregnancy. Three patients have undergone subsequent pregnancy. In 2 patients the operation caused premature labour at the thirty-second and thirty-fourth weeks; 1 infant died. There was no maternal death. Opinions are divided regarding the indications for valvotomy in pregnancy. Burwell and Metcalfe advocated medical treatment and held that surgery should be performed only when "the safer procedure of interruption is not practicable". The authors admit the efficacy of medical therapy in mild cases, but believe that patients *in extremis* demand valvotomy and run no greater operative risk than if they were non-pregnant. In selected cases, then, they consider valvotomy preferable to termination of pregnancy.

GENERAL GYNAECOLOGY

Stress incontinence

Observations on the female urethra and bladder

ARDRAN, HAMILL and SIMMONS (1956) presented further observations on the female urethra and bladder. A study has been made of additional patients with and without stress incontinence In addition to these, studies have been made on young boys and girls with disorders of the genito-urinary system, these confirm previous conclusions, and also

59 patients demonstrated downward and forward movement of the bladder neck on

closure of the urethra in cases of stress incontinence as compared to the normal. A study of 13 patients before and 9 months after operation showed no relationship of the posterior urethrovesical angle to the cure of stress incontinence.

Bladder control in the female

JEFFCOATE and ROBERTS (1956) discussed bladder control in the female Although many workers have confirmed the authors' radiological findings, others have made

original 206 cases with 281 series of cysto-urethrographs have been re-examined. The bladder base as seen from the side in normal women is more or less flat, with an upward

rotate at the triangular ligament, contraction of the detrusor muscle is demonstrated radiologically by an ovoid shape to the bladder and by crenations; at the same time the urethra dilates, when micturition is established the posterior urethrovesical angle is sometimes partly restored; restoration of the normal anatomy of the urethrovesical junction is one of the last features of micturition, and is the result of contraction of intrinsic muscle (? involuntary, ? voluntary) in the area and not of contraction of the

with stress incontinence can hold the urine in the urethra temporarily; this explains why operations which only buttress the urethra and tighten its musculature can improve stress incontinence without restoring the posterior urethrovesical angle.

Ovarian function after the menopause

Cytological evidence

RANDALL, BIRTCH and HARKINS (1957) discussed ovarian function after the menopause. A review has been made of the cytology of vaginal smears from 1,768 patients. The series comprised: 183 women evaluated for oestrogen effect one or more years following hysterectomy, 112 others observed for evidences of oestrogen effect one or more years following castration by removal of the ovaries or irradiation; and 1,473 women evaluated for oestrogenic effect one or more years following spontaneous cessation of their periods; these patients had received no oestrogenic therapy for 6 or more months prior to the date of the smear. The results of the study showed cytological evidences of oestrogen effect (in cervical smears taken by the Ayre spatula) in women examined after (*a*) spontaneous cessation of menstruation, (*b*) hysterectomy when the ovaries were preserved; and (*c*) castration. The majority of the smears demonstrated persistence of oestrogenic effect for more than 15 years following hysterectomy, a finding which suggests that when the ovaries are preserved they may continue to function. The proportion of cases in which oestrogenic effect persisted for years after removal of both ovaries suggests that oestrogens may be derived from tissues other than the ovaries, although there is little indication that subsequently the extra-ovarian oestrogens may be provided in larger amounts to meet the deficiency caused by oophorectomy. The results of the investigation indicate that the so-called extrapelvic oestrogen appears able to protect not more than 50 per cent of apparently normal women from the possibility of atherosclerosis and osteoporosis, or from the inevitable development of atrophic epithelial changes in the genito-urinary tract, and it is doubtful whether prophylactic oophorectomy is ever justified. As in the authors' experience castration results in deficiency of oestrogenic effect in 40 per cent of women within 5 years, and in over 50 per cent of women after 10 years, it seems probable that oophorectomy performed routinely whenever hysterectomy is indicated might be a contributing factor in the eventual disability of more women than now seem destined to develop a malignancy of the ovary.

Congenital absence of the vagina

THOMPSON, WHARTON and TE LINDE (1957) discussed congenital absence of the vagina. The condition results from an embryological arrest in the development of the lower portion of the Müllerian system, there is usually also an absence of the uterine fundus and cervix, but the ovaries are normal since they have a different origin; associated anomalies of the urinary tract always involve the kidneys and ureters, as the urethra and bladder are not derived from the urogenital fold. The construction of an artificial vagina is indicated in three types of cases: (1) those with an absent vagina and a normally functioning uterus; (2) patients who are married or are making plans for marriage; (3) to minimize psychological trauma; this indication is open to question. The methods used for construction of an artificial vagina include: (A) non-surgical, intermittent pressure made by a mould just below the external urethral meatus, (B) surgical; (1) intestinal transplantation, (*a*) small intestine, (*b*) rectum; (2) pedunculated flaps, (*a*) simple labial and thigh flaps, (*b*) tubed pedicle flap from thigh; (3) simple reconstruction with insertion of form; (4) simple reconstruction with insertion of inlay graft over form (McIndoe, 1938). The present authors have used the McIndoe method in 32 cases of congenital absence of the vagina: urological examination of 17 of these cases showed major congenital urinary tract anomalies in 8 instances, minor anomalies of the renal collecting system and of bone (spina bifida) were also present. 4 of the patients had previously been treated by Wharton's method without success. The three main principles of the McIndoe method are: dissection of an adequate

than the anatomical result in evaluating the success of the operation.

Chorioncarcinoma

Treatment with Methotrexate

A case of chorioncarcinoma treated with Methotrexate (4-amino-N-IO-methyl-pteroylglutamic acid) is recorded by HOLLAND (1958). A white, married woman, aged 33 years, was referred to the author's institute for chorioncarcinomatous metastases to the lungs In the course of her third pregnancy she had had intermittent vaginal bleeding, and repeated vaginal haemorrhages occurred post-partum, curettage was performed, and the curettings were interpreted as chorioncarcinoma. A total hysterectomy with salpingo-oophorectomy was performed, a submucosal tumour infiltrating the posterior uterine wall was present, and microscopic study of this specimen confirmed the diagnosis of chorioncarcinoma Radiography of the chest revealed multiple haematogenous metastases Examination on admission revealed a mass at the apex of the vaginal vault, it was uncertain whether this was a post-operative haematoma or a recrudescent tumour; the titres of urinary gonadotropin were elevated. Treatment with Methotrexate was begun, with initial doses of 25 milligrams daily the first course was 125 milligrams. The pulmonary lesions diminished progressively, the mass in the pelvis became smaller and eventually was unidentifiable. The gonadotropin titre fell to a level normal in an oophorectomized woman, and all the subsequent titres were normal. The platelet count fell progressively, and on two occasions the reticulocyte count fell below 1 per cent; no important changes in haemo-

Haemophilus vaginalis vaginitis

BREWER, HALPERN and THOMAS (1957) discussed *Haemophilus vaginalis* vaginitis A study has been made of 211 patients whose ages ranged from 20 to 63 years, all of whom complained of leucorrhoea; the investigation was made with wet mounts, Gram-stain

in staining reactions were frequently encountered. Treatment with Terramycin and polymyxin B vaginal suppositories gave by far the best results; however, because of the occurrence of *Candida albicans* subsequent to Terramycin–polymyxin B therapy, the authors now use hexathidine with excellent results; *H. vaginalis* disappeared from the flora without treatment in three instances.

Monilial vaginitis

Treatment with nystatin

JENNISON and LLYWELYN-JONES (1957) described the treatment of monilial vaginitis with nystatin, an antifungal antibiotic derived from *Streptomyces noursei*, and compared it with gentian violet. Fifty-three women suffering from vaginal candida infections were treated with nystatin. All had typical lesions; any patient with associated trich[illegible] vaginitis was excluded. Two positive cultures were obtained in [illegible] of the vagina by speculum, 2 pessaries contai[illegible] In the control group of 36 patients the [illegible] After 1 week the vagina was again inspe[illegible] repeated in 1 month If candida was pre[illegible] and another swab taken. Most of the pat[illegible] 1 week were transferred to the nystatin group, together with 6 women in whom gentian violet produced a reaction necessitating termination of treatment. No adverse local reaction to nystatin occurred. Of the 53 patients receiving nystatin 43 were free of infection after 1 week; of 56 treated with gentian violet only 17 were cured. Sixteen of 18 not responding to gentian violet were cleared by nystatin. One month after treatment the relapse rate was 46 per cent in the gentian violet group, and 21 per cent in the nystatin group. One patient was cured with oral nystatin. Since nystatin greatly reduces the yeast population of the intestinal tract, combined pessary and oral treatment may be indicated for persistent or recurrent infections.

Postmenopausal bleeding

ADAMSON, BROWN and MYER[illegible] bleeding. The patients repre[illegible] gynaecological wards of the R[illegible] Most patients gave a history of [illegible] was often observed. The type of bleeding was of no value in differentiating between benign and malignant disease With regard to the aetiology, the series included 173 cases of carcinoma of the cervix, 150 cases of prolapse, 134 cases with functional endometrial changes and 95 cases of senile vaginitis. Haemorrhage was found to be malignant in origin in 28 per cent of cases, and this group included a relatively high proportion of nulliparae. Cases of bleeding in patients aged 51–55 years were relatively common, but bleeding from a benign lesion was seen much less frequently among patients belonging to older age groups. A study of the data failed to lend support to the contention that a late menopause is a common occurrence in women with carcinoma of the body of the uterus. It appeared that there was a greater likelihood of encountering cases of malignant disease among patients who had ceased to menstruate for a relatively long period. A number of patients delayed seeking treatment because they believed that the haemorrhage was a minor incident. In one-fifth of the cases of malignant disease the delay exceeded 6 months, and in several instances the disease had reached such an advanced stage that even palliative treatment was not possible. There were 2 cases in which the diagnosis of carcinoma of the cervix was established only on microscopical examination of the amputated cervix after an operation for repair of the pelvic floor. The findings served to emphasize the need for a full diagnostic curettage in all cases.

Climacteric haemorrhage

Association with carcinoma of the body of the uterus and diabetes mellitus

the menopause has occurred when more than 1 year has elapsed since the last period. The author employs these criteria in a report on 55 cases of carcinoma of the body of the uterus and 249 women suffering from diabetes mellitus. In both series the onset of spontaneous menopause was found to occur later than in normal women. Furthermore, there was a relative increase in the incidence of climacteric haemorrhage. When glucose-

haemorrhage. A menopause induced by radiation is not a predisposing factor in the causation of carcinoma of the uterine body, but the incidence of this neoplasm is unduly high among patients with diabetes mellitus

Radiological pelvimetry and hysterosalpingography

Intravaginal measurement of radiation dose

Intravaginal measurement of radiation dose incident to radiological pelvimetry and hysterosalpingography was discussed by BERMAN and SONNENBLICK (1957) In the authors' technique the instruments used for measuring consist of an electrometer and 3 inter-

were made, comprising lateral, inlet and outlet views of the pelvis and lateral view of the

interpretation of ovarian dosage in pelvimetry and in hysterosalpingography because of

against the benefits to be derived from its use.

Primary ovarian carcinoma

Assessment of radiotherapy

LATOUR and DAVIS (1957) presented a critical assessment of the value of radiotherapy in primary ovarian cancer. Any form of treatment which may be distressing and even potentially dangerous to the patient must be of indisputable value. That combined surgery with post-operative irradiation is superior to surgery alone must be proved. An analysis of 202 cases was therefore undertaken, with a 5-year follow-up in 98·5 per cent. Five stages of the disease are recognized: Stage 0 represents carcinoma *in situ* with no invasion of the stroma; Stage 1, gross malignancy but the tumour localized; Stage 2, breakdown of the ovarian capsule, but no manifest spread; Stage 2A, bilateral ovarian involvement without evidence of other pelvic metastases; Stage 3, pelvic dissemination; Stage 4, extrapelvic metastases; Stage 4L, liver involvement. On account of the severity of the disease, laparotomy alone was performed in 22·3 per cent cases. Unilateral removal of the adnexa with or without hysterectomy was done in 22·7 per cent, bilateral salpingo-oophorectomy in 52·4 per cent. Of 73 hysterectomies, the total operation was performed in 26 per cent. Post-operative radiotherapy was given in 56 cases, either immediately after operation or when considered necessary. From 1930 to 1938 it was received by 30 3 per cent patients; from 1939 to 1950, when treatment was potentially better, by 26·5 per cent. The technique is described. In the early and late stages of the disease, surgery alone predominated; in Stages 2A and 3, post-operative radiotherapy combined with surgery was commoner. In Stages 4 and 4L, many patients were too ill to receive post-operative irradiation. The over-all 5-year survival rate of 37·6 per cent compares favourably with previous reports of 14·5 to 37 9 per cent The 5-year to 10-year survival rates are higher with surgery alone than when combined with radiotherapy; indeed, patients receiving combined treatment from 1930 to 1938 show a poor survival. Review and evaluation of the literature shows that conclusions have not been corroborated by statistics, cases have been improperly selected, the basis of comparison has been inadequate and impressions have been given the status of facts. This analysis of patients receiving combined treatment from 1930 to 1938 suggests that irradiation not only failed to help them but was actually deleterious, surgery alone giving better results. As palliative therapy, radiotherapy was not only poor but produced radiation sickness and other related symptoms. In Stages 2A, 3 and 4, where it should have been of the greatest value, it failed to establish its importance.

Advanced pelvic cancer

Exenteration operations

Exenteration operations in the treatment of advanced pelvic cancer were discussed by DOUGLAS and SWEENEY (1957). A study has been made of 23 patients operated upon during the period 1948–54: in 16 cases the operation was total exenteration, consisting of resection of the lower ureters, bladder, vagina, uterus, adnexa, lower sigmoid colon, rectum, pelvic peritoneum, and pelvic lymph nodes; in 7 cases anterior exenteration was performed, consisting of resection of the lower ureters, bladder, vagina, uterus, adnexa, pelvic peritoneum, and pelvic lymph nodes, in 10 of the total exenterations the ureters were transplanted to the skin and in 6 into the bowel with formation of [illegible] in all the anterior exenterations the ureters were im[illegible] site of carcinoma was the cervix uteri in 18 [illegible] endometrium in 3 cases, urethra in 1 case a[illegible] radiation previously; 13 had had one or m[illegible] ranged from 34 to 72 years. All the patients were investi[illegible] including examination under anaesthesia, pyelography, [illegible] blood chemistry determinations; the need for and exten[illegible] to the patient and her responsible relatives and the [illegible] manence of anatomical changes were stressed. All the o[illegible] were performed under general anaesthesia. an interspinous transverse incision was used in 14 cases and a longitudinal incision in the remainder; 17 operations were done as abdominoperineal

operation may be indicated in a very limited number of patients and should be performed only with the basic idea of cure, not palliation. The most suitable cases are those with spread to the bladder or rectum, but with no lateral spread.

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USE OF THE ILEUM IN UROLOGICAL PROCEDURES

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INTRODUCTION

The incorporation of an isolated loop of the lower ileum into the urinary tract has been carried out in recent years for a variety of purposes, and although the number of such operations performed is not yet large it seems clear that their usefulness has now been proved and the soundness of their basic principles established.

The operative procedures have been of two kinds. In one group a part of the urinary tract (the ureter or the bladder) which has been damaged by injury or altered by disease is remodelled so as to restore it anatomically to serve its original purpose. In another group an isolated portion of lower ileum is made to serve as a conduit for urine, as an alternative method of urinary diversion to uretero-colic anastomosis.

Anatomical considerations

The terminal part of the ileum, because it is mobile and because it has a good blood supply, is convenient for incorporation into the urinary tract. Since the mesenteric vessels are arranged in arcades, the transverse part of the arcade can be divided between ligatures without risk to the blood supply of the gut. When an isolated loop of ileum is prepared, the mesenteric pedicle is usually sufficiently long to allow the loop to be brought into apposition with the bladder or to be rotated into the line of either ureter without dangerous tension. Radiological studies have shown that vigorous peristaltic contractions continue after a segment of ileum has been isolated. The mucosa of the ileum continues to produce mucus

after its incorporation into the urinary tract and this is a slight disadvantage, for sometimes inspissated mucus may hinder the free flow of urine along the urethra; rarely, however, does any serious trouble arise.

Physiological considerations

The mucous membrane of the colon has the power to absorb differentially chloride ions and sodium ions, sometimes to the detriment of the patient (Parsons and his colleagues, 1952*a*, 1952*b*). Before the ileum came to be used extensively in urological procedures, it was therefore desirable to know the nature of any electrolyte absorption across its mucous membrane into the blood stream.

If the ureters in the dog are transplanted into an isolated short segment of small intestine one end of which is exteriorized, there is a slight rise in non-protein nitrogen in the first post-operative week, but no electrolyte imbalance (Matsumoto, 1938, Mersheimer, Kolarsick and Kammandel, 1951). McLean and Fais (1952) replaced the whole of one or both ureters in the dog by a segment of ileum and no hyperchloraemic acidosis was noted. Tasker (1953) reconstructed the bladder of the dog by inserting an open loop of ileum as a flat graft. No significant changes in the electrolyte concentrations of the blood before and after operation were found. Specimens of venous blood, draining from the graft when the reconstructed bladder was filled with urine, were analysed for their electrolyte concentrations and the results were compared with those from a similar analysis of the blood of a systemic vein; blood coming from the graft had a higher potassium content than that from the systemic vein, suggesting that potassium was absorbed, possibly in excess, by the mucosa of the ileum from the urine in the bladder; no significant absorption of sodium or of chloride was found.

Perfusion studies using an isolated loop of ileum in a woman, and also a bladder to which a loop of ileum had been anastomosed, were carried out by Pyrah and Raper (1955) It was shown that small amounts of chloride and of sodium were absorbed into the blood stream in almost equal amounts; it was also shown that if the potassium concentration of the fluid in contact with the ileal mucosa was three times greater than that in plasma, there was a net movement of potassium ions from the fluid in the lumen of the ileum into the blood stream

The experimental evidence suggests, therefore, that hyperchloraemic acidosis will not be a serious problem, but that under certain circumstances an elevation of the serum potassium level may occur It is known from the authors' experience of uretero-colic anastomosis that serious electrolyte imbalance depends not only on the differential absorption of electrolytes from the colon but also upon ascending renal infection derived from the faeces-laden colon. Since in cases in which the ileum has been incorporated in the urinary tract ascending renal infection has not occurred with any frequency in the remodelling operations, though it occurs occasionally when the ileum is used as a conduit to the exterior (ileal ureterostomy), the homeostatic mechanisms of the kidneys are usually unimpaired and biochemical imbalance is rarely found. Clinical experience has so far amply supported this view. A few cases of hyperchloraemic acidosis when loops of ileum have been used have been reported by Bricker (1952) and Wilson (1953), but such experiences are unusual.

The following are some of the uses to which an isolated loop of ileum has been put in the urinary tract:

(1) To enlarge a contracted bladder—ileocystoplasty, uretero-ileocystoplast
(2) To replace a segment, or the whole, of the ureter or ureters.
(3) To act a a urinary conduit to the exterior—ileal bladder (or ileal urete stomy or ileal segment), ileocystostomy.
(4) To reconstruct an excised bladder—ileal urethrostomy.
(5) For revision procedures for cases of failed uretero-colic anastomosis.

The use of the ileum as a conduit for urine to the exterior (ileal bladder or ilea ureterostomy), and also the construction of a true ileal bladder as a reservoir (ileo-urethral anastomosis), have been described in an earlier article in these volumes (Pyrah, 1956). The present article describes the other uses to which an isolated loop of ileum can be applied in the urinary tract.

PREPARATION OF THE ILEAL LOOP

In the operations to be described, since the method of isolation of the ileal loop is common to them all, it is convenient to discuss this first.

Preparation of patient

Prior to operation the patient is given a low-residue diet and 250 milligrams of aureomycin 4-hourly for 4 days; on the two mornings before operation the colon is washed out and, on the evening before, an enema is given.

Incision

The abdomen is opened by a left paramedian incision extending from a short distance above the umbilicus to the symphysis pubis. The patient is placed in a moderate Trendelenburg position and the small intestine, other than the loop, together with the caecum is packed into the upper abdomen by moist swabs; an accurate assessment can then be made of the length of the loop and its suitability for the purpose in hand.

Preparation of loop

A coil in the lowest 3 feet of ileum is chosen as being most suitable. For use in the operation of ileocystoplasty, the selected loop of ileum should have a mesentery which is sufficiently long and mobile so that after it has been prepared it can be brought into the pelvis in apposition with the bladder without tension. If the loop is to replace a ureter, it must be possible to rotate it to the appropriate side of the abdominal cavity, in the line of the ureter, without endangering its blood supply.

At the lower point selected for the division of the ileum, usually some 8 inches above the ileo-caecal valve, the vascular arcade nearest to the gut is divided between ligatures and the resulting opening in the mesentery is prolonged at a right angle to the intestine; sometimes a second vascular arcade must be divided so as to give an opening in the mesentery of 4–5 centimetres in height. A similar opening is made in the mesentery at a distance above the first, which is long enough to provide a loop of the appropriate length. The mesenteric pedicle of the isolated loop should be wide enough to minimize the chances of rotation. The ileum is then divided between clamps at the selected places; a Cope's crushing clamp is suitable for this

purpose, the detachable blades of the clamp being left in position after the handle has been removed. An end-to-end or lateral anastomosis, usually in front of the isolated loop, is made to restore continuity of the intestine; the opening between the anastomosis and the mesentery of the loop is closed by interrupted sutures which join the back of the anastomosis to the anterior leaf of the mesentery.

ILEOCYSTOPLASTY AND URETERO-ILEOCYSTOPLASTY

In the operation of ileocystoplasty a contracted bladder is enlarged by anastomosing to it either a closed loop of ileum or one or more open loops of ileum employed as flat grafts.

A contracted bladder may lead to distressing frequency of micturition which, quite apart from its social inconvenience, may endanger health through loss of sleep; moreover, a contracted bladder is not infrequently associated with reflux to the kidneys or with a spastic or strictured lower end of a ureter, either of which conditions may lead to gradual impairment of renal function.

Previously reported cases

Tizzoni and Poggi (1888) were the first to carry out the operation of ileocystoplasty in the experimental animal.

The first ileocystoplasty in a human being was done by Rutkowski, a Polish surgeon of Cracow, in 1898, in a 12-year-old boy with ectopia vesicae; he isolated a loop of ileum 6 centimetres in length, which was opened on its antimesenteric border. The graft so obtained was used to reconstruct the anterior wall of the bladder. The operation was not entirely successful because the patient was still incontinent. Later in the same year von Mikulicz (1898) performed a similar operation in two stages on a patient with ectopia vesicae Shoemaker (1909) carried out ileocystoplasty as a two-stage procedure for a contracted bladder which was probably tuberculous, one kidney having been previously removed. He first prepared an isolated ileal loop and anastomosed the remaining ureter to it, bringing the lower end of the loop through an opening in the abdominal wall After an interval to allow the tuberculous bladder to heal, the ileum was anastomosed to the bladder at a second operation.

Scheele (1922) anastomosed the centre of an ileal loop to the bladder to relieve contracture, he then joined the two ends of the loop to each other to produce a [illegible] collected from the literature [illegible] 10 of the Ringplastik type; [illegible] velaire (1950).

Interest was revived in the operation of ileocystoplasty by Couvelaire in 1950, who described 5 of his own cases of plastic enlargement of the small healed tuberculous bladder. He anastomosed the isolated caecum to the bladder in 3 cases. In 2 other patients in which a small contracted tuberculous bladder was associated with severe hydronephrosis of the sole remaining kidney, he first did a nephrostomy and later an ileocystoplasty, joining the dilated ureter to the ileal loop by lateral anastomosis. The patients were relieved of their distressing frequency. Cibert and his colleagues have reported 60 cases of ileocystoplasty for contracted tuberculous bladder; in a series of papers these workers also described the pathology of the contracted tuberculous bladder (Cibert, 1953; Cibert and Durand, 1956; Cibert, Durand, Foret and Soler, 1954).

The authors have reported 18 cases of ileocystoplasty for contracted bladder due to various causes, for uninhibited bladder, for restoring to normal the capacity of a bladder after extensive partial cystectomy and also for revision procedures (Pyrah and his colleagues, 1955; Pyrah, 1957). Wells (1956) reported a collected series of 55 cases of ileocystoplasty, 23 of which were done for tuberculous contracted bladder, 22 for non-tuberculous contracted bladder, 7 for Hunner's ulcer or interstitial cystitis and 3 for other conditions; there was an operative mortality of 9 per cent. In 47 cases a closed ileal loop was used, while in 8 an open loop of ileum fashioned into a flat graft was employed.

Two cases of ileocystoplasty with relief of symptoms were reported by Ferris (1957). A series of 12 cases of ileocystoplasty for contracted bladder, resulting from healed tuberculosis in 8 cases and from interstitial cystitis in 4 cases, was reported by Jacobs (1957); in 7 of the 8 tuberculous cases the dilated solitary ureter was implanted into the end of the loop.

An open loop of ileum, the gut being divided along its antimesenteric border to produce a flat graft, has been used to enlarge the bladder, by Sabadini and Ducassou (1951), Tasker (1953), Pyrah and Raper (1955), Ichikawa and Kurokawa (1955), and Yeates (1956). Details are referred to below.

Pathological considerations

Non-tuberculous chronic cystitis

In the healed contracted bladder resulting occasionally from non-tuberculous chronic cystitis the muscular coat may remain of more or less uniform thickness, although the muscle has undergone patchy fibrosis following the attacks of recurrent inflammation; the capacity of such a bladder may vary from 80 to 150 millilitres.

Healed tuberculous bladder

The healed tuberculous bladder which has undergone a moderate degree of contraction may still have a capacity of 100–150 millilitres. In the active stage of the disease the tuberculous ulceration penetrates the mucosa into the muscle coat which, when healing has occurred, undergoes extensive fibrosis. The resulting deep scarring of the vault and base of the bladder, often with the formation of numerous septa reaching down to the ureteric orifice, may be recognized cystoscopically; some healthy mucous membrane may remain.

In more advanced cases of tuberculous bladder contracture (thimble bladder) the capacity may be reduced to 30 millilitres or even less. In such cases the trigone does not appear to take part in the contracture but remains smooth and may even be slightly more distensible than normal. The detrusor is much reduced in size and is converted into an irregularly thickened, nodular, fibromuscular roof or lid for the dilated trigone. Consequent upon the fibrosis and the contraction of the detrusor, the ureteric orifices come to occupy a position at the upper and outer corners of the contracted bladder.

Other changes gradually follow in the ureters and in the urethra as a result of the contraction of the bladder cavity; they are probably due to a rise of pressure in the bladder between the acts of micturition, consequent upon the continued excretion of urine into it. Ultimately the valvular action of the ureteric orifice ceases to be effective and the orifices are forced open resulting in reflux of urine;

hydro-ureter, affecting first the lower and then the upper segments, and later hydronephrosis accompanied by deterioration in renal function, occur. The dilated ureteric orifice may be one centimetre or more in diameter and a cystogram may demonstrate that the tiny bladder, the ureter and the renal pelvis now form one continuous reservoir for the urine. In some cases fibrosis of the lower end of the ureter with stricture formation secondary to healed tuberculous ulceration and possibly to streptomycin therapy may protect the remaining kidney and ureter from the effects of reflux, but leads to hydronephrosis.

The external vesical sphincter, so long as it remains intact, preserves urinary continence. The rise in intravesical pressure may result in dilatation of the prostatic ducts, the wide-open ostia of which can be seen on urethroscopy; two or three openings of dilated ducts may be seen on each side of the prostatic urethra and a urethrogram shows that they enter dilated and bulbous cavities within the prostate; in other cases one or more ducts in each lobe of the prostate undergoes great dilatation, giving rise to diverticula. In some cases the bladder neck has undergone fibrous contracture and the prostatic urethra is not then dilated Similarly, if one kidney and ureter have been previously excised for tubercle the remnant of the ureter may become dilated.

Active tuberculous disease of the bladder or of the remaining kidney has, in the authors' series, been a contra-indication to ileocystoplasty. Some surgeons, however, have not excluded such cases from operation.

Interstitial cystitis

Interstitial cystitis with or without Hunner's ulcer is an occasional cause of contracted bladder occurring usually in women, and causing persistent and sometimes troublesome pain in addition to distressing frequency.

Indications for operation

The authors have performed ileocystoplasty using a closed loop of ileum in 22 cases, as shown in Table I. The indications have been to enlarge a contracted bladder which has resulted from long-standing chronic cystitis, from healed tuberculosis or from interstitial cystitis; to restore a bladder to its normal size after a large part of it has been excised for carcinoma; to correct the frequency of micturition resulting from an uninhibited bladder; and as a revision procedure for failed uretero-colic anastomosis.

TABLE I

Indications	*Cases*	*Deaths*
For a contracted bladder		
Long-standing chronic cystitis		
Ileocystoplasty	1	—
[illegible]		
[illegible]	8	1
[illegible]	6	2
[illegible]	4	—
To reconstruct the bladder after extensive partial cystectomy	1	—
For uninhibited bladder	1	—
As a revision procedure	1	—
Total	22	3

The operation

The operation may be performed *entirely* as a transperitoneal procedure, a method which the authors have favoured; alternatively, it may be done as a combined extraperitoneal and intraperitoneal operation.

Transperitoneal ileocystoplasty

The isolated loop of ileum is prepared as the first step in the operation and its length varies inversely with the size of the bladder which is to be enlarged; thus, for a thimble bladder having a capacity of 30 millilitres or less, a loop of ileum 25–40 centimetres in length may be used; for a bladder having a capacity of 120–160 millilitres, a correspondingly shorter length is adequate.

A transverse incision is made through the peritoneum on the posterior wall of the bladder at the place selected for the anastomosis. The flaps of peritoneum are dissected forwards and backwards to expose the underlying detrusor muscle.

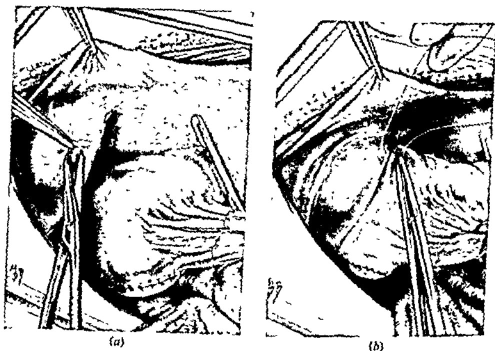


Fig. 63.—Operation of ileocystoplasty. (*a*) Ileal loop has been isolated, proximal end has been infolded, clamp remains on distal end for implantation of ureter. (*b*) Ileal loop is stitched by continuous suture to back of bladder.

(*By courtesy of the Editor of Journal of Urology*)

The loop of ileum is brought into apposition with the bladder and the lower leaf of the divided peritoneum reflected from the detrusor is sutured to the serosa of the loop by continuous or interrupted stitches. Using a continuous suture the seromuscular coat of the ileum is joined to the bladder muscle, the stitches taking a good bite but not the entire thickness of the latter. This suture line should extend the entire width of the bladder (Fig. 63).

The bladder is then opened transversely across its full width either by scissors or by a diathermy needle. Part or the whole of the detrusor muscle may be excised.



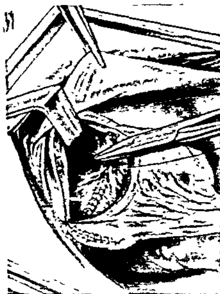
(a)



(b)



(c)



(d)

FIG 64 —Operation of ileocystoplasty. (a) Opening is made into cavity of bladder. (b) Opening of same size is made into lumen of intestine. (c) Continuous suture approximates mucosae of ileum and bladder. (d) Last suture line is continued.

(*By courtesy of the Editor of Journal of Urology*)

as described later. It is best to open the bladder first in the middle line in order to ascertain the position of the ureteric orifice of the remaining kidney, so as to avoid injuring it. Bleeding points are controlled by diathermy fulguration.

The bladder neck is inspected. Very often it is wide open because the prostatic urethra is dilated. If, however, it has undergone fibrous contracture a generous V from the posterior lip of the contracted neck should be excised by diathermy.

An opening comparable in size to that in the bladder is made in the ileum and a continuous through-and-through suture is inserted, the stitch taking the whole thickness of the ileum and the deeper muscular layers of the detrusor together with the vesical mucous membrane, the two mucous membranes being brought into accurate apposition. It is usually convenient to interrupt the stitch at the proximal end of the anastomosis (Fig. 64). A similar anterior row of through-and-through stitches is then inserted to close the ileum and the bladder and a further continous suture joins the seromuscular coat of the ileum to the detrusor muscle of the bladder in front of the anastomosis. Finally, the anterior leaf of the peritoneal covering of the bladder is sutured to the peritoneal coat of the intestine to extraperitonealize the anastomosis. It has not been deemed desirable to stitch down the loop of ileum to any part of the peritoneum.

The abdomen is closed with a drain placed in the cave of Retzius, which is easily opened by the finger, the end of the tube being carried down to the region of the anastomosis in case of urinary leakage. An indwelling catheter is placed in the urethra.

Excision of the detrusor muscle

In the smallest healed tuberculous bladders the contracted fibrosed detrusor is thickened and nodular, and when the peritoneum is dissected from it there is a considerable seepage of blood. In such cases it is best to excise the detrusor of the bladder as recommended by Cibert and his colleagues (1954) Little more than the trigone with the dilated ureter attached is left behind, but it is found that the subsequent ileocystoplasty can be done more easily. The ileal loop then becomes a substitute for the entire detrusor muscle.

Preparatory to excising the detrusor, a sound is passed along the urethra into the bladder and is made to present beneath the bladder wall in order to demonstrate the position of the bladder cavity which otherwise may not be easy to find. The dome of the bladder is then opened with scissors in the sagittal plane in order to avoid damage to the ureteric orifices. The bladder having been opened, the ureteric orifice is inspected and if necessary its patency is ascertained by passing a ureteric catheter along it. The mucous membrane of the trigone, which may be more capacious than normal, is usually supple, vascular and healthy, and its limits are readily recognized; the mucous membrane of the detrusor may be absent or, alternatively, much reduced in extent. Following the initial sagittal cut into the bladder the detrusor is bisected and its resection is rendered easy, the two halves being cut away to the edge of the trigone of the bladder, removing the vascular perivesical fibrofatty inflammatory tissue. Bleeding is arrested by diathermy fulguration. The edges of the trigone are then anastomosed to the ileal loop using two rows of sutures in the manner previously described. The cave of Retzius is drained and an indwelling catheter is placed in the urethra.

Combined extraperitoneal and intraperitoneal method

A combined extraperitoneal and intraperitoneal technique for the exposure and resection of the bladder and for the subsequent ileocystoplasty may be used (Cibert and his colleagues, 1954) A left lower abdominal paramedian incision is made down to the symphysis pubis and the bladder is exposed extraperitoneally. Its anterior surface is separated from the pubic symphysis. The peritoneum is then opened by a transverse incision at its point of reflection on the dome of the bladder, and through this opening the base of the small bladder is freed from the peritoneum and is rendered mobile so that the detrusor muscle may be resected Through the peritoneal opening the ileal loop is drawn and prepared as previously described and is allowed to prolapse through the opening to the trigone. The peritoneum is closed around the mesentery of the loop using interrupted stitches The ileal loop is then anastomosed to the edges of the trigone by two rows of sutures. A catheter is placed in the urethra.

Varieties of ileal loop

The following different varieties of ileal loop have been used.

(1) Both ends of the loop are closed and infolded and the centre of the loop is anastomosed by a wide opening to the posterior surface of the bladder or to the trigone after the detrusor has been excised.

(2) The proximal end of the loop is closed and infolded and the distal end is anastomosed to an opening on the posterior surface of the bladder or to the trigone. The width of the loop is usually sufficient to allow an adequate anastomosis to be made. Drainage of urine from the loop is assisted by peristalsis

(3) Both ends of the loop are closed and infolded. The anastomosis of the loop to the bladder is then made as near as possible to the distal closed end in order to avoid a bulbous dilatation of the distal end of the loop.

(4) In the Scheele Ringplastik operation, the centre of the loop is anastomosed at its antimesenteric border by a wide opening to the dome of the bladder or to the trigone, after the detrusor has been excised. The two ends of the ileal loop are then joined to each other, making a ring of ileum

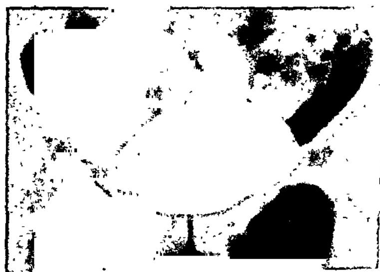
The operation of ileocystoplasty is sometimes associated with residual urine and this has been found to occur even when the bladder neck has been resected. The circumstances under which such residual urine accumulates have been studied with the image intensifier by Hanley (1956) Hanley showed that as a result of peristaltic action urine tends to collect in the distal horn of an ileal loop, the centre of which has been anastomosed to the bladder (Fig 65), he also showed that the Scheele Ringplastik operation similarly encourages the accumulation of residual urine. The methods of anastomosis described in paragraphs (2) and (3) appear to be unassociated with residual urine, and are therefore to be preferred.

Treatment of the ureter of the remaining solitary kidney

If the bladder has undergone a moderate degree of contracture but the ureter is not yet dilated, the bladder is enlarged by anastomosis to an ileal loop and the ureter is left untouched. Such a procedure is especially suitable in cases of fibrous contracture of the bladder resulting from long-standing non-tuberculous cystitis in which ureteric reflux has not yet occurred.



(a)



(b)

FIG 65.—Retrograde cystogram in case of ileocystoplasty. (a) Bladder and

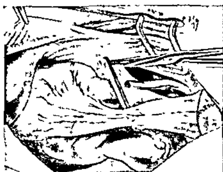
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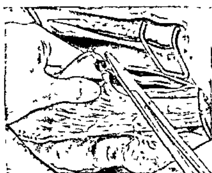
[illegible] *(By courtesy of the Editor of Journal of Urology)*

If there is ureteric reflux of the remaining solitary kidney, as is commonly found in advanced cases of healed contracted tuberculous bladders, the ureter may be dealt with in one of two ways.

(1) The lower end of the dilated ureter may be mobilized, ligated close to the bladder and divided The upper dilated end is then anastomosed to the appropriate horn of the ileal loop (uretero-ileocystoplasty, Fig. 66). The authors have used this method because they have found a satisfactory uretero-ileal anastomosis


(a)


(b)


(c)


(d)

Fi

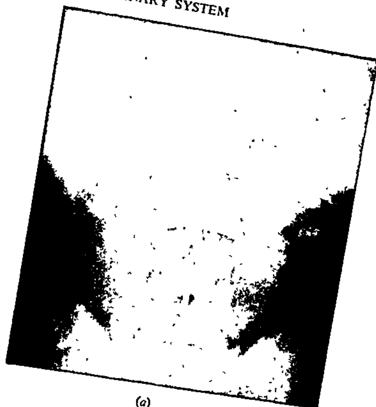
(*By courtesy of the Editor of Journal of Urology*)

will protect a hydronephrotic kidney and allow of its gradual return to normal (Fig. 67). The uretero-ileal anastomosis may be made using different techniques.

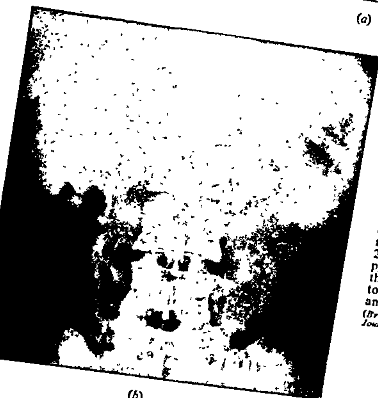
The divided ileum may be partly closed and infolded by catgut sutures, leaving the central part of its cut end unsutured and with an opening which is large enough to enable the surgeon to suture the end of the divided ureter to the mucous membrane of the ileum by interrupted stitches (*see* Fig. 66). A second row of sutures in front and behind the anastomosis so made joins the adventitia of the ureter to the seromuscular coat of the ileum, so as to produce a slight invagination of the anastomosis; the valve-like opening thus produced prevents reflux.

Alternatively, the end of the ileum may be closed completely and infolded; the ureter is then joined to the ileal loop one inch or so below the closed end using one of the standard techniques, such as the methods of Coffey (1911) or Leadbetter (1951).

(2) The dilated ureter may be left attached to the bladder after resection to the trigone, the ileal loop being joined to the trigone; care must be taken during suturing not to cause any narrowing of the ureteric opening (Cibert and his colleagues, 1954). Cibert (1953) showed in such a case that a hydronephrosis and



(a)



(b)

FIG. 67.—(a) Intravenous pyelogram showing hydronephrosis and hydro-ureter of remaining kidney, associated with healed contracted tuberculous bladder (May, 1953). Uretero-ileocystoplasty done 27.5.53. (b) Intravenous pyelogram (11.6.56); there has been a return to normal of kidney and ureter.

(By courtesy of the Editor of Journal of Urology.)

hydro-ureter returned to almost normal 12 months after operation; he believed that this return to normal had been achieved because of the reduction of the hydrostatic pressure of urine within the reconstituted bladder, the tendency to reflux being consequently reduced.

Either of these two techniques would appear to give good results, and which will ultimately be found to be the better must await the report of further cases.

Ileocystoplasty with an open loop

In this method the loop of ileum is isolated as described above; it is then opened by dividing it along its antimesenteric border, thereby converting it into a flat graft the edges of which can be sutured to an opening in the bladder.

The first case in which an open loop of ileum was used to enlarge a bladder was reported by Sabadini and Ducassou (1951). The operation was done in a man aged 48 years for a contracted tuberculous bladder which was enlarged by the insertion of an isolated loop of ileum 15 centimetres in length and opened on its antimesenteric border.

Following experimental work on the dog, Tasker (1953) used an open ileal loop to enlarge a contracted bladder. A loop 8 inches in length having been isolated, both ends being left open, it was divided into two equal portions which were opened on the antimesenteric borders, giving two open flat grafts of ileum; the two grafts were then sutured together laterally, making a flat rectangular graft approximately 3×4 inches. The graft was sutured on to the opened dome of the bladder in order to enlarge it. The capacity of the bladder as a result of the operation was increased from 6 to 10 ounces; the patient made a good recovery and there was very little residual urine.

Ichikawa and Kurokawa (1955) treated one case of healed contracted tuberculous bladder in a man of 55 years, using Tasker's technique The capacity of the bladder was increased from 40 to 200 millilitres. The patient made a good recovery and there were only 20 millilitres of residual urine. Pyrah and Raper (1955) reported one case in which a flat graft of an opened ileal loop was used to restore the size of the bladder to almost normal, following an extensive partial cystectomy carried out for carcinoma of the bladder in a woman of 65 years.

Ichikawa and Kurokawa (1955) also used a modification of Tasker's operation. The isolated ileal loop was opened on the antimesenteric border and divided into two equal parts which were then united by their lateral borders, making a rectangular patch. In the middle of each of the four sides of this rectangular patch the adjacent parts of the cut edge of the ileum were stitched to each other, converting the rectangular patch into a cup-shaped graft which was readily adapted for suturing to the dome of the opened bladder. The patient made a successful recovery.

Yeates (1956) described a further modification of the open ileal loop for use in ileocystoplasty in cases of small contracted bladders.

After-treatment and complications

Ileocystoplasty is a major operation It carries the risks of an intestinal anastomosis as well as those of the anastomosis of the loop to the bladder. Careful attention must be given to fluid balance in the immediate post-operative period to prevent or correct intestinal ileus. There is commonly some degree of abdominal

distension for a few days. An indwelling catheter should be retained in the urethra for 10 days.

Mechanical obstruction may occur from adventitious adhesions around the intestinal anastomosis or to the ileal loop. It is possible that the loop with its mesentery may act as a band resulting in mechanical obstruction, but the authors have not found any report of such a case. Peritonitis may occur from break-down of the intestinal anastomosis. Drainage of urine from the ileal-vesical anastomosis has occurred; it may be expected to occur more frequently when the open flap is used because of the longer and more complicated suture lines. Gangrene of the loop caused by rotation of its pedicle has been reported, and would require immediate excision of the loop and drainage of the bladder.

Results

The clinical results of ileocystoplasty are usually very good. In the great majority of the authors' cases frequency of micturition has been completely relieved, giving sleep at night and improvement in general health; in a few it has been partially relieved. In only two of the authors' cases has frequency persisted owing to the presence of residual urine. In the series of cases of ileocystoplasty collected by Wells (1956), in the 31 cases in which the late result was known, excellent and very good results were reported in 18, in 9 there was fair or moderate improvement, and in 4 cases there was no improvement. The open graft gave excellent results in 6 of 8 cases.

Micturition

In the early weeks after operation micturition is sometimes slow and the patient feels the need of a little manual pressure over the abdominal wall in order to void urine. The patient is compelled to take time over the act and there may be a sense of imperfect emptying. After a few weeks this symptom tends to disappear.

Radiographic studies

The function of the bladder after ileocystoplasty can be studied by retrograde cystogram, by the image intensifier and by estimations of residual urine.

If an opaque medium is introduced into the bladder by catheter, the bladder and the loop are both filled. In a successful case a good wide stoma can be seen. On screen examination the intestinal loop can be seen to undergo active peristaltic contractions. Serial radiographs taken at intervals of a few seconds, or direct inspection with the image intensifier (Hanley, 1956), show the phases of contraction and relaxation of the ileal loop (Fig. 68). In an occasional case the ileal loop remains inactive but this would appear to be a temporary phase. When the act of micturition begins, the opaque medium is expelled partly per urethram; the ileal loop, however, becomes distended and it is then stimulated to undergo rhythmic contractions and gradually to empty. The act of micturition is thus biphasic, but some time after operation the two phases may take place in rapid sequence; gradual adaptation usually seems to take place and the act of micturition becomes nearly normal.

Residual urine

The residual urine has been tested in a number of cases and has usually been found to be small in amount or absent A cystogram with the bladder distended



(*a*)

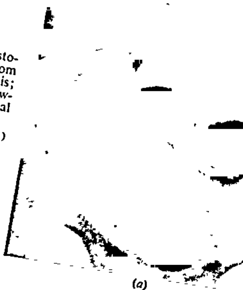


(*b*)

FIG 68 —(*a*) Typical retrograde cystogram following ileocystoplasty. Opening between bladder and loop remains widely open; loop fills well with opaque medium (*b*) Serial radiological studies of ileal loop in case of ileocystoplasty. Radiographs have been taken at intervals of a few seconds Pictures show irregular outlines demonstrating peristaltic activity; there are phases of marked contraction and dilatation of different parts of the loop.

(*By courtesy of the Editor of Journal of Urology.*)

FIG 69.—Case of uretero-ileocystoplasty for small bladder resulting from long-standing tuberculous cystitis; (a) showing bladder filled; (b) showing a very small amount of residual urine after voluntary voiding.
(*By courtesy of the Editor of Journal of Urology*)


(a)


(b)

and also following micturition, in a man who had uretero-ileocystoplasty 4 years previously, is seen in Fig. 69; he now has a very small amount of residual urine. Clinically he micturates either not at all or only once during the night, and 3-hourly to 4-hourly by day. In other cases there have been small amounts of two or three ounces of residual urine not giving rise to clinical symptoms and not resulting in infection of the urine. In a small minority of cases a moderate or considerable amount of residual urine has been found.

When, therefore, a loop of ileum which contains muscle of different physiological properties from that of the vesical musculature is anastomosed to the bladder, complete integration of muscular action does not always appear to be achieved; in most of such cases, however, the defects noticed on radiological examination are not clinically evident.

Cystoscopic appearances

Cystoscopically a satisfactory union can be seen to have been achieved between the ileal and the vesical mucous membranes, and a good wide stoma is usually obtained. The folds of the mucous membrane of the ileal loop retain their normal appearance. The authors have not themselves so far noted any contraction of the stoma, but it is possible that if an ileal loop is anastomosed to a badly scarred and fibrosed detrusor contraction of the stoma may take place; such a case has been reported.

Electrolyte imbalance

No patient in the authors' series has had electrolyte imbalance except one for whom ileocystoplasty was done as a revision procedure. This patient had previously had, some years before, uretero-colic anastomosis for hydronephrosis of a solitary remaining kidney, the bladder being contracted. The blood urea had gradually risen to 250 milligrams per cent and she had a severe hyperchloraemic acidosis. It was decided to revise the ureterocolic anastomosis, which was done by detaching the ureters from the sigmoid colon, making an ileocystoplasty and anastomosing the ureter to the loop. The acidosis persisted for at least the first 2 post-operative months; the authors believed that it was due to the persistence of poor renal function consequent upon the renal infection resulting from the uretero-colic anastomosis rather than from the ileocystoplasty. Table II shows the blood electrolyte levels in 6 cases.

TABLE II

BLOOD ELECTROLYTE LEVELS FOLLOWING ILEOCYSTOPLASTY IN 6 CASES

Operation	*Time after operation*	*Post-operative*				
		Blood urea (mg per 100 ml.)	*Sodium (mEq/l)*	*Potassium (mEq/l)*	*Co_2 combining power (mEq/l) bicarb.)*	*Chloride (mEq/l)*
Ileocystoplasty	1 yr. 11 mths	17·0	139	3·7	24·5	99·2
Uretero-ileocystoplasty	14 mths.	13·4	145	4·5	24·2	109·0
Ileocystoplasty	4 mths	13·4	135	4·6	24·5	106·0
Ileocystoplasty	4 yrs. 3 mths	25·2	141	4·5	25·7	99·2
Ileocystoplasty	4 yrs. 6 mths.	25·0	135	4·3	31·5	96·5
Uretero-ileocystoplasty	3 yrs. 1 mth	23·7	145	5·4	32·5	102·5

Infection

Almost every case has had sterile urine within a few weeks of the operation. Sometimes the appearance of the urine, which contains flakes of inspissated mucus, has worried the patient until it has been explained to him that this was not the result of infection.

ISOLATED SEGMENT OF ILEUM USED TO REPLACE THE URETER

Nissen (1940) used an isolated segment of the small intestine to replace the obliterated lower half of the left ureter in a patient who had developed a peri-ureteral abscess following an operation for the removal of a stone from the ureter. This was the first occasion on which an isolated segment of ileum was used to replace the whole or part of one or both ureters The following ureteric lesions have since been treated by this means: (1) benign ureteric tumours; (2) high division of the ureter by trauma or operation; (3) hydro-ureter and hydronephrosis; and (4) fibrosis of ureters after the creation of cutaneous ureterostomies.

Indications

Ureteric tumours

Only a few ureteric tumours can be treated in this way. It must be as certain as possible that the tumour is a primary ureteric tumour and not a "seedling" from a tumour of the renal pelvis. The authors reported 3 cases of ureteric tumours in which the ureter was excised from a point just above the tumour down to and including its orifice and was then replaced by an isolated ileal segment (Pyrah and Raper, 1955). A fourth patient has been similarly treated but died 14 days after the operation from paralytic ileus. Of the 3 cases originally reported 1 had a malignant tumour and died of carcinomatosis 18 months after his operation. The remaining 2 are alive and well, 5 years and 4½ years after operation, and have not developed any more papillomas. It seems safe to assume that their ureteric tumours were primary tumours and not seedlings from a small renal pelvic tumour, and it has proved justifiable to have saved the kidney on the affected side. These ureteric tumours were judged to be primary because good pyelograms failed to show any renal tumours above them and because the tumours themselves had become rounded, presumably by long-continued moulding in the ureter, and were therefore assumed to have been so long in the ureter that any possible primary tumour in the renal pelvis would have been large enough to show with certainty on a pyelogram. For this operation to be justifiable the kidney must be worth saving, and the patient fit to withstand a major abdominal operation. Otherwise the best treatment is a nephro-ureterectomy. If there is any bladder-neck obstruction or prostatic hypertrophy this should be corrected at the same time or there is a risk of dangerous distension of an "ileal ureter" due to the back pressure. One such patient was admitted urgently to hospital with a volvulus of his distended and elongated ileal ureter.

High division of the ureter during pelvic operations

The urete [illegible] operation or may be deliberately [illegible] the pelvic organs or colon. In ci[illegible] that it cannot be

re-implanted in the bladder it is possible to use an ileal segment to bridge the gap. Examples of this have been reported by Longuet (1948), Muller (1950), Graham and Goligher (1954), Annis, Hunter and Wells (1954). Kusunoki and his colleagues (1956), in a report of 10 cases treated since 1951 in which isolated ileum or sigmoid colon had been used to replace the ureter, included 5 in which this method had been used to cure uretero-vaginal fistulas. Whether this method is used or not depends upon the state of the affected kidney and the condition of the patient. If the kidney is healthy and the patient fit the best treatment is to re-connect the ureter to the bladder by an isolated ileal segment. This is especially important if the opposite kidney is in any way diseased. If the affected kidney is not functioning and is infected and the opposite kidney is healthy the best treatment will be to remove the kidney. If there is any doubt about the opposite kidney it is best to bring the divided ureter to the surface as a cutaneous ureterostomy until accurate assessment of renal function can be made. If necessary its re-union to the bladder with isolated ileum can be made at a second operation

Hydro-ureter and hydronephrosis

Due to mechanical ureteric obstruction.—Foret and Heusghem (1953) reported a case in which bilateral hydronephrosis and hydro-ureter due to stenosis of the ureteric orifices was relieved by anastomosing an isolated ileal loop to the bladder and uniting the ureters to the loop. Baum (1954) reported 4 cases of hydronephrosis and hydro-ureter in which the ureter was replaced by isolated ileum. The ureters were obstructed by strictures in 3 patients and by metastatic carcinoma in the fourth. In 1 patient previous operations at the pelvi-ureteric junction made it impossible to anastomose the ureter or pelvis to the ileal segment but it was successfully anastomosed to the dilated lowest calyx Ortved (1954) used an ileal segment to replace a ureter obstructed by a stricture following removal of a stone. Moore and his colleagues (1956) reported 4 cases in which ureters, obstructed by fibrous tissue after pelvic operations, were re-connected to the bladder with an isolated ileal segment In 1 patient both ureters were obstructed and both were divided above the obstruction and implanted into the upper half of an isolated ileal segment the lower end of which was anastomosed to the bladder Ulm (1958) used ileal segments to replace the sole remaining but strictured ureter in 2 patients who had undergone previous operations for stone.

For megalo-ureter.—Swenson, Fisher and Cendron (1956) used ileal segments to relieve megalo-ureter. They reported that in a group of 60 children with unilateral or bilateral megalo-ureter there were 15 in whom pressure records from the lumen of the ureter showed absence of ureteric peristalsis This may sometimes be due to infection, but if the infection cannot be cured or if there is no infection to account for the lack of peristalsis such a ureter can be replaced by an isolated ileal segment. This was done in 6 cases with good results In the hope of preventing reflux it is considered of benefit to reduce the calibre of the ileal segment and this necessitates 2 operations At the first, the loop is isolated from the alimentary tract, and its lumen reduced by excising about three-quarters of its circumference, taking away the antimesenteric portion. The new tube is then created by suturing the cut edges and each end of the loop is brought through the abdominal wall. One month later the whole of the megalo-ureter is excised from the pelvi-ureteric junction to the

bladder and the new ureter sutured into place, bringing it through an opening in the mesentery of the colon. An end-to-end anastomosis is made between the renal pelvis and the ileal ureter and the lower end is anastomosed to the bladder low on the posterior wall.

Fibrosis of ureters resulting from cutaneous ureterostomies

MacDonald and Katana (1957) reported 2 patients who had cystectomy and bilateral cutaneous ureterostomies for carcinoma of the bladder. Both subsequently developed stenosis of one ureter with repeated attacks of pyelonephritis in the obstructed kidney. In both patients the diseased ureter was excised and replaced by an isolated ileal segment with satisfactory results.

Technique

The incision must be long for important anastomoses have to be performed at each end of the incision and adequate space must be obtained.

Peristalsis in the segment

It is more important that when in position the isolated loop should lie comfortably without risk to its mesentery than that it should be isoperistaltic. It is a happy state of affairs when both conditions can be fulfilled although it is not essential to have an isoperistaltic loop. One patient previously reported by the authors (Pyrah and Raper, 1955) has had an antiperistaltic ileal segment replacing the lower half of his right ureter for 5 years without any ill-effects.

Anastomosis between ureter and ileal segment

Because there will be reflux of urine into an ileal ureter when the bladder contracts, it is advisable to form a valvular connexion between the ureter and the upper end of the segment to protect the kidney from the rise of pressure. The principle of the projecting nipple can be used either by pulling about 1·5 centimetres of ureter through to the lumen of the bowel or by invagination of a mucosa-to-mucosa type of anastomosis. Alternatively, a valvular anastomosis such as a Coffey or Leadbetter type can be used. Some protection will be afforded to the kidney by the expansibility of the ileal ureter.

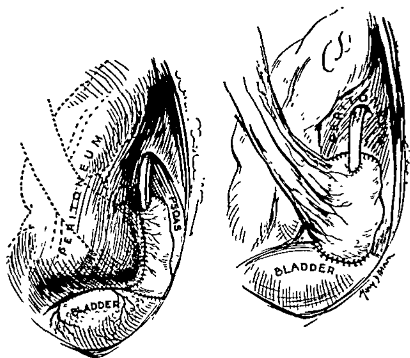
Anastomosis between ileal segment and bladder

The end of the ileal segment is anastomosed to the bladder at any convenient point. If the ureter has been removed for a tumour it is essential to be certain of excising the ureteric orifice, and this is best done by a combined intravesical and extravesical route. The incision round the orifice can then be closed and the incision in the dome and anterior wall of the bladder used for the ileo-vesical anastomosis.

Some attempt should be made to fix the new ureter to the posterior abdominal wall. This may be most conveniently done by stitching it to the bed of the excised ureter, or by bringing the ileal segment completely outside the peritoneum taking care not to restrict its blood supply (Fig. 70).

Post-operative care

The most usual post-operative complication has been some degree of ileus. No form of urinary tract drainage or splinting has been needed other than an indwelling urethral catheter which has usually been used for 7–10 days. An example of the pre-operative and post-operative films of one patient is shown in Fig. 71.



Fi

(By courtesy of the Editor of Journal of Urology)

ILEUM USED AS A CONDUIT TO THE EXTERIOR

As already stated, the operation of ileal bladder or ileal ureterostomy, as a method of urinary diversion alternative to uretero-colic anastomosis, has been referred to in another article in *British Surgical Practice, Surgical Progress* (Pyrah, 1956), and this should be referred to for details of the indications and the technique.

A modification of ileal ureterostomy, which may be especially suitable for cases of urinary incontinence in paraplegic patients, has recently been described by Cordonnier (1957), under the name of ileocystostomy.

An isolated ileal segment is fashioned in the usual way and continuity of the intestine is established by end-to-end anastomosis The bladder neck is then closed In the female this procedure is carried out by dividing the urethra at the bladder neck in the cave of Retzius and infolding it into the bladder with two layers of stitches, the distal end of the urethra is similarly closed. In the male, closure of the bladder neck is made transvesically in order to avoid any possible interference with ejaculation. The vault of the bladder is then opened and the ileal segment is anastomosed to it. Sometimes it is desirable to remove a portion of the dome of the bladder before making the anastomosis and this step is advisable in order to prevent persistent residual urine. The distal end of the ileal segment is


(a)


(b)


(c)


(d)

FIG 71 —Skiagrams of a case of primary carcinoma in lower third of left ureter treated by excision of part of ureter and replacement by a loop of ileum. (a) Medium-grade left hydronephrosis. (b) Filling defect in lower third of left ureter. (c) Post-operative intravenous pyelogram shows some reduction in hydronephrosis after uretero-ileocystoplasty (d) Post-operative cystogram shows reflux from bladder up ileal loop; no reflux up residual part of ureter

(By courtesy of the Editor of British Journal of Surgery)

then brought out through the abdominal wall as an ileostomy at a point midway between the right anterior superior iliac spine and the umbilicus.

This operation avoids the transplantation of the two ureters into the loop of the ileum since the ureters are left attached to the trigone of the bladder. It seems possible that imperfect drainage from the dependent bladder may lead to persistence of infection The operation has proved satisfactory in 3 cases which have been followed for periods of 11, 12 and 15 months respectively

USE OF A LOOP OF ILEUM IN REVISION PROCEDURES

In a small proportion of patients who have had the operation of uretero-colic anastomosis as a method of urinary diversion and in whom clinical symptoms of increasing severity have followed attacks of ascending renal infection and electrolyte imbalance, it sometimes becomes necessary to revise the anastomosis in order to save life. Following recurrent attacks of ascending renal infection, the functional capacity of the kidneys to excrete the excess of electrolytes which are absorbed from the urine in the colon is gradually reduced; patients affected in this way may suffer recurrent attacks of severe acidosis which may lead to renal invalidism or even to coma and death. In a patient with only one kidney which is defective as a result of ascending infection (as when uretero-colic anastomosis has been done for a tuberculous contracted bladder, one kidney having been previously removed), the margin of safety may be small and the risk of a fatal outcome from recurrent attacks of renal infection correspondingly greater. In such cases revision procedures are necessary to save life (Pyrah, 1956, 1957).

The form of the revision procedure will depend upon whether the bladder is still present or whether it has been removed, and if it is still present whether it is of normal size or contracted, healthy or diseased

(1) If the bladder is intact and healthy, or if there is a fistula (for example, a vesico-vaginal fistula) which can be repaired, the ureters may be detached from the sigmoid colon and re-anastomosed to the bladder with the help of a U-loop of ileum.

(2) If the bladder is healed and contracted, for example, from pre-existing tuberculosis, a failed uretero-colic anastomosis may be successfully replaced by an ileocystoplasty.

(3) If the bladder has been previously removed for carcinoma, a failed uretero-colic anastomosis may be replaced by an ileal bladder (ileal ureterostomy)

The authors have re-implanted the ureters into the bladder in 3 patients who had previously had a uretero-colic anastomosis which had proved to be a clinical failure. In one patient the operation had been done for a very large vesico-vaginal fistula which it had been found impossible to repair In another patient, a uretero-colic

of treatment; the operation proved to be a failure and the ureters were re-implanted into the bladder one year later, a loop of ileum being used to bridge the gap between the detached ureter and the bladder.

In another case a uretero-colic anastomosis had been done several years ago for a contracted healed tuberculous bladder; in the succeeding years the patient gradually went into renal failure, because of recurrent attacks of ascending infection; her life was saved by making an ileocystoplasty and implanting the ureter which had been detached from the sigmoid into one end of the ileal loop.

Details are given of two of these cases.

Case No. 1.—Re-implantation of the ureters into the bladder. The patient, a female aged 42 years, had uretero-sigmoidostomy performed in October, 1951, for a very large vesico-vaginal fistula which had followed an *operation* for prolapse of the uterus in [illegible] sloughing of the anterior vaginal wall [illegible]

[illegible], both ureters were re-implanted, as [illegible] procedure, into the bladder, using a U-shaped ileal loop 14 inches *in length*: the centre of the loop [illegible] bladder and the ureters [illegible]

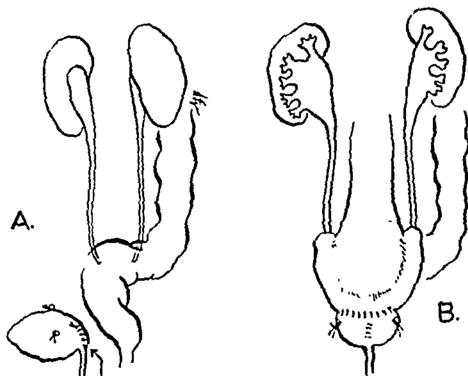
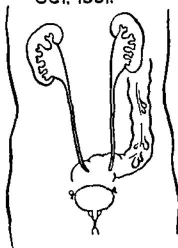


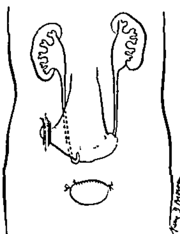
FIG. 72.—Case 1. A woman, aged 42 years, who underwent bilateral *uretero*-ileocystoplasty as revision procedure for failed uretero-colic anastomosis. (A) Repaired vesico-vaginal fistula (B) Ileocystoplasty.

(By courtesy of the Editor of Journal of Urology)

Case No. 2.—The patient, a man aged 54 years, had had several operations for the relief of







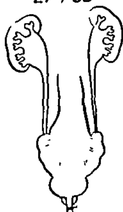


Fig. 73.—Case 2 A man aged 54 years Diagram shows various operations.
(By courtesy of the Editor of Journal of Urology)

eventually die from renal failure unless a further revision procedure was carried out. In April, 1956, the ileal loop was detached from the bladder which was repaired with three [illegible]

In 4 other cases ileal bladders (ileal ureterostomy) have been made as revision procedures for patients in whom the operation of uretero-colic anastomosis has proved to be a clinical failure because of recurrent attacks of renal infection with electrolyte imbalance. In all these cases the late results have so far been satisfactory, though all have been operated on in the last 3 years.

SUMMARY

(1) A loop of the terminal portion of the ileum can often be incorporated into the urinary tract with advantage. The anatomical arrangements and the physiological properties of such a loop do not seem to introduce undue hazards.

(2) The operation of ileocystoplasty has now been done sufficiently often to establish it as a useful procedure for the relief of cases of contracted bladder; the later results are usually satisfactory though the periods of follow-up, as yet, are comparatively short.

(3) Replacement of a part or the whole of a damaged or diseased ureter has now been reported in a few cases with good immediate results. One late undesirable result is referred to. Further cases must be studied before its final place can be assessed.

(4) Ileal bladder (ileal ureterostomy) gives excellent results as a method of urinary diversion in certain cases of spina bifida with urinary incontinence. Its use as a method of urinary diversion following cystectomy for carcinoma of the bladder is controversial. Ileocystostomy may have a place for the relief of urinary incontinence in paraplegic patients.

(5) A loop of ileum has a useful place in certain revision procedures for cases of failed uretero-colic anastomosis.

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ABSTRACTS RELATING TO THE USE OF THE ILEUM IN UROLOGICAL PROCEDURES

Ileocystostomy for neurogenic bladder

CORDONNIER (1957) described the use of ileocystostomy for neurogenic bladder. The operation, which consists of urinary diversion utilizing an isolated ileal segment and a portion of the bladder, has been used successfully in 3 cases of meningomyelocele. In the

author's technique the abdomen is opened through a mid-line suprapubic incision, and routine appendicectomy is performed. After the ileal segment, which is established in the usual way, has been isolated, the bladder is opened. The next step is closure of the vesical neck, and this may be done extravesically in the female patient, the urethra being severed at the bladder neck and closed with a double layer of No. 00 chromic catgut sutures, the distal urethra being closed separately. In the male the closure is made transvesically to avoid possible interference with ejaculation. In cases in which the bladder is small in capacity, the ileal segment is anastomosed directly to the dome of the bladder; if, however, there is marked flabbiness of the detrusor musculature, the excess bladder is removed and the anastomosis made between the remaining bladder and the ileal segment; failure to excise a sufficient amount of bladder resulted, in one of the author's cases, in persistent residual urine. The bladder may be drained, prior to completion of the anastomosis, by cystostomy or by a urethral catheter passed through the segment which is brought to the abdominal wall; on about the tenth day an ileocystogram is made through the suprapubic catheter and if the anastomosis is intact the suprapubic catheter is removed. The method should be used for cases of extensive neurological involvement of the detrusor musculature with urinary incontinence, and cases of upper urinary tract damage from infection, and is applicable to other cases if the ureterovesical mechanism is not obstructed, for example, extensive urethral scarring with multiple perineal fistulas.

Ileocystoplasty for bladder contracture

Experiences with ileocystoplasty for the relief of bladder contracture were recorded by JACOBS (1957). The diversion of the urine into the large bowel by uretero-colic anastomosis has generally given satisfactory prospects of well-being and longevity; the ultimate result is influenced much more by the nature of the lesion for which the diversion is performed than by subsequent renal damage and electrolyte imbalance which may occur. A review of 210 patients on whom the operation of uretero-colic anastomosis was performed during the previous 25 years revealed that 76 were surviving; 55 of the total had lived 5 years and over, 21 of them for more than 10 years and 8 for more than 15 years. The conditions for which the more recent operation of ileocystoplasty was performed were tuberculous disease in 8 cases and intractable interstitial cystitis in 4. In the author's technique when the ureter is to be divided from off the bladder and implanted into the bowel loop, it is inserted one inch or so distal to the closed-off end of the coil on the appropriate side, although he favours the Leadbetter method of uretero-intestinal anastomosis, separation of the seromuscular layer from the mucosa is more difficult in dealing with ileum than with large bowel, and a modified Coffey technique has therefore been used in most cases. It is advantageous to intubate the ureter with polythene tubing, which is inserted through the ileo-vesical opening and down the ureter alongside a Foley catheter draining the bladder. the tube is left in position for 5 days and drainage by the Foley catheter is continued for a further 5 days; with this technique there is little risk of seepage through the anastomosis Observations on the results reveal instances of complications, including obstructive anuria, in cases in which uretero-ileocystoplasty was performed without intubation.

Total replacement of ureter

Total replacement of the ureter with small intestine was described by ULM (1958). The author reports 2 successful operations, in each of which a conduit between renal pelvis and bladder was established by retroperitoneal transplantation of an ileal segment; one of these is believed to be the first instance in which the procedure was used successfully in a patient with only one kidney. The 2 patients were males, aged 50 years and 34 years respectively, both of whom had histories of recurrent renal calculi and had had previous operations on both kidneys, in case II the right kidney had been removed, and the patient was admitted because a permanent nephrostomy tube, present in the left kidney, had become blocked with grumous phosphatic material. It is recommended that if the involved kidney has been operated upon previously, initial efforts should be made through the upper lateral portion of the incision to uncover the lower pole of the kidney:

Ureteral substitution by isolated ileal loop

interrupted sutures of No. 000 chromic catgut, which were reinforced with a second external layer; the proximal portion of the ileal loop was brought through the posterior

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77, 437.

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eflux occurs through the ileal segment to the renal pelvis; there has been no recurrence of calculi, suggesting that there may be some factor in the ileal secretion which may digest or otherwise eliminate the organic matrix of stones.

Ureteral substitution by isolated ileal loop

operations, including cystectomy, prostatectomy, and seminal vesiculectomy; both had developed pyelonephritis and eventually exhibited similar problems, the necessity for preserving the remaining kidney and for providing a good functional ureter which would

interrupted sutures of No. 000 chromic catgut, which were reinforced with a second external layer; the proximal portion of the ileal loop was brought through the posterior peritoneal layer to the anterior abdominal wall, delayed return of bowel motility and

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NEUROSURGERY

THE MANAGEMENT OF ACUTE HEAD INJURIES

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Head injuries, mainly from road accidents, have increased in number steadily in recent years and there can now be few general hospitals in the country which do not regularly have several such cases under their care. The growing interest in their management also reflects the realization that head injury accounts for the majority of fatal accidents. The advent since World War II of an increasing variety of effective antibiotics, the ready availability of blood transfusion and the more efficient treatment of compound limb fractures and the like have all lowered the mortality of other injuries considerably, and in so doing have thrown into relief the serious mortality from head injury. The majority of the deaths from head injury occur in the early period, three-quarters of them within the first 24 hours, and although there are many problems in the management of head injury in the later stages and of the sequelae which may follow, yet it is to the early management that attention has to be directed if the results are to be improved. Brain injuries and their complications are described in *British Surgical Practice*, Vol. 2, p. 349; this present article is concerned with certain features in the management of the acute head injury, particularly the blunt head injury with unconsciousness, which has a bearing on the mortality rate

GENERAL CONSIDERATIONS

The first requirement is diagnosis of the extent of the injury on admission, and subsequent observation to determine whether progress is satisfactory or if complications are developing; second, nursing and general management until the patient has recovered full consciousness, and prevention and treatment of the various complicating factors of the unconscious state.

The importance of the first examination cannot be over-emphasized for, apart from allowing a more accurate diagnosis to be made of the extent of the injury, it forms a base on which subsequent progress may be judged. Much of the anxiety which often attends the management of a head injury in the acute stage stems from the fact that an accurate assessment of the patient's conscious level and of the presence or absence of neurological abnormalities has not been made at the outset. There are two main reasons for this. The patient may be quite uncooperative and

not allow of an ordinary neurological examination, or the presence of other injuries makes the examination difficult. Yet, there are few cases in which it is not possible to record accurately the level of the patient's consciousness, the size and reaction of the pupils, the tone and power of the limbs on command or stimulation, the presence or absence of reflexes, and the state of the plantar responses. The later management of these patients may be undertaken by several doctors and nurses; it is therefore better to avoid the use of technical terms in describing the conscious level of the patient and, instead, to record briefly what the patient can do. *The statement that a patient has responded* verbally to his name, or obeys simple commands, or responds briskly to pinprick in all four limbs, is much more valuable to all concerned subsequently than such phrases as "partly-responding" or "semi-comatose". If a patient has apparently recovered completely from his initial concussion and then lapses again into unconsciousness—the so-called "lucid interval"—it is obvious to all that a complication has developed; but it is more difficult to estimate progress if the patient has been unconscious throughout, and it is in these circumstances that such careful recording is invaluable. To this should be added the charting of the patient's temperature, pulse, blood pressure, respiration and the pupillary reactions at regular intervals as the occasion demands. Again, an obvious change in these signs, such as a marked slowing of the pulse or pupils previously reacting becoming dilated and fixed, is readily noted, but experience has shown that if a diagnosis of cerebral compression has to await the appearance of such late signs, then the chances of

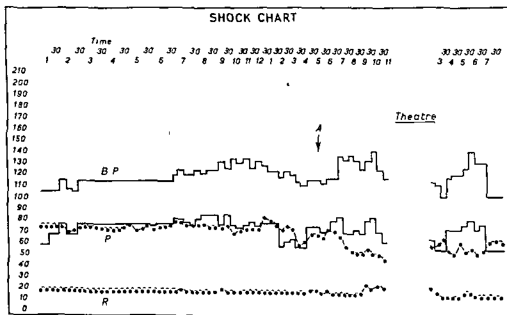


FIG 74.—Observation chart to show the onset of cerebral compression. Note at point A, 20 hours after the accident, that the pulse begins to fall and the respiration and blood pressure begins to rise. B P =Systolic and diastolic blood pressure, P=Pulse, R=Respiration

(*By courtesy of the Editor of Nursing Mirror*)

successful intervention are so much less. The aim in observation of these patients is to detect the earliest signs of complication and to act accordingly.

An example of an observation chart which has been found useful in such cases is shown in Fig. 74. This illustrates the way in which at 20 hours after an accident to a young patient, who had received a severe head injury and was unconscious from the outset, it could be seen that the pulse began to fall and the blood pressure to rise. This, together with the nurses' observation that the limbs on the right side of the body had become spastic, allowed a diagnosis to be made of cerebral compression with subsequent operation and removal of a large subdural haematoma at a time when the pupils of this patient were equal and reacting briskly to light. The patient subsequently made a good recovery. Reliance is placed not on any one single observation but on the general trend of the patient's progress, and it will vary from case to case as to whether deterioration is witnessed mainly by a change in the physiological state of the patient as shown on the observation chart, or a deepening of his conscious level, or a change in the neurological picture, or, usually, by a combination of these.

Pattern of progress

As a general rule it may be said that if a patient is recovering satisfactorily from a head injury his level of consciousness should be steadily improving and his observation chart smooth. Any deterioration in the patient's condition once improvement has begun, particularly if this is in his conscious level, may mean a complication and, indeed, this should be assumed to be so until the contrary is proved. Although cerebral compression from intracranial bleeding is always foremost in the surgeon's mind, and rightly so since this is amenable to surgical treatment, it should not be overlooked that there are several other causes for deteriora- [illegible]

conscious level and accentuation of any neurological signs that may already be present. Unless this is remembered, the cause of a deterioration may erroneously be assumed to be intracerebral and lead to fruitless intracranial exploration.

General care

Posture

These patients should be nursed flat and on their sides, and whilst unconscious turned from side to side day and night 2-hourly. Although there is a theoretical advantage in nursing these patients with the head raised, in that it allows freer venous drainage from the head and in that way may lower intracranial pressure, the dangers from inhalation of such a posture far outweigh such an advantage.

Temperature regulation

The temperature in the rectum should be recorded regularly and controlled by [illegible] of temperature regulation [illegible] ove fatal. The temperature [illegible] and to this end patients should not be covered too much in the early stages, a single sheet is normally sufficient. An open window and a small electric fan will also help, but if more is required to lower the temperature cold sponging or even iced water rectal enemas

should be given. These simple measures should not be confused with the particular treatment by hypothermia to which reference is made later. The control of temperature in the unconscious patient after a head injury should be a routine nursing matter and in most cases it can be achieved by the measures outlined above.

Sedatives

Sedatives should not be employed regularly and, if one has the advantage of a side room in which to nurse the patient, are better avoided altogether. Restlessness is often worsened by a high temperature or a full bladder and attention to these details is often far more effective than drugs. If drugs have to be used then a small dose should be given in the first instance, since after head injury patients vary considerably in their tolerance and at times a small dose can be surprisingly effective. Phenobarbitone, 100–200, milligrams (1½–3 grains) intramuscularly may be tried for extreme restlessness, although in the author's experience this is much less effective than a small dose of paraldehyde (3–5 millilitres intramuscularly for an adult). Chlorpromazine (Largactil), 25 milligrams, intramuscularly has also proved effective in several cases and in these doses is not unduly sedative and does not mask the development of other signs. All these drugs should be used sparingly and rarely is a more narcotic agent needed. If on occasion morphine has to be prescribed, 5 milligrams (1/12 grain) which may be repeated is a safer routine than a higher initial dose.

The management of the chest and nutrition are dealt with in greater detail below.

Shock

This is not a common accompaniment of the uncomplicated head injury, although it may occur with extensive scalp lacerations or compound fractures of the skull where there has been extensive blood loss, and in these instances blood transfusion is, of course, necessary In other cases a careful search, particularly of the chest and abdomen, should be made for other injury before accepting the situation as a complication of the head injury.

CHEST COMPLICATIONS

Anoxia

After a severe head injury there is a high morbidity and mortality from chest complications, some of which are preventable, and it is still not sufficiently realized how important it is to maintain a free airway in the unconscious patient for 24 hours in the day It is no exaggeration to say that more lives would be saved every year by attention to the airway after head injury than by any other single measure. Moreover, it is well known that the brain cannot tolerate even a few minutes' anoxia and yet such a situation is seen not infrequently after a head injury, the upper respiratory tract being filled with secretions and the patient cyanosed and breathing rapidly and irregularly. In these circumstances the fate of injured but recoverable brain tissue is in jeopardy unless full oxygenation is achieved. Proof of this can often be seen in the casualty department where the airway of an unconscious patient is satisfactorily cleared with resulting improvement in the patient's level of consciousness and even in the neurological status.

Inhalation of vomitus and blood

That the chest is particularly vulnerable after head injury attended by unconsciousness can be seen by enumerating some of the ways in which the chest may be implicated. By far the commonest cause is the inhalation of vomitus at the roadside or in the early hours after the injury, or of blood trickling down the nasopharynx from a fractured base of skull or from a facial injury and entering the trachea; such a calamity is promoted if the patient is transported on his back or nursed other than flat and on his side. Inhalation of this kind may result in massive pulmonary collapse and immediate death, but an almost equally dangerous condition can arise in those patients who seem to survive the first onslaught. Thus, the main air passages may be cleared by simple treatment such as suction, but blood and vomitus may already have entered the bronchioles and remain there. This, as the hours pass, is followed by areas of peripheral pulmonary collapse, steadily decreasing the pulmonary ventilation, and at the best infection will follow in a few days, or at the worst a subsequent minor incident will prove fatal.

Chest injury

In other cases, and they are becoming more frequent with the severity of modern accidents, there may be a combined head and chest injury. This is a particularly lethal combination and in the unconscious patient it is not always easy in the initial stages to diagnose the associated chest injury with any accuracy. Multiple fractured ribs with or without a pneumothorax or haemothorax can be easily overlooked unless the possibility is borne in mind and radiography of the chest carried out early in doubtful cases.

Pulmonary fat embolism

Pulmonary fat embolism, particularly in patients who have associated limb fractures, may also occur and is by no means uncommon. It accounts for a proportion of cases which used to be diagnosed "hypostatic bronchopneumonia after head injury".

Acute pulmonary oedema

Then again there is the direct effect of the brain injury on the lungs themselves. Brain-stem compression, whether from cerebral oedema or secondary to an intracranial clot, can produce rapidly an acute pulmonary oedema in which quantities of thin blood-stained fluid may be secreted and, unless the cerebral compression can be relieved, lead to asphyxia. This condition has been well known to neurosurgeons in a variety of circumstances for many years and more recently has been produced experimentally by Cameron (1948).

Bronchopneumonia

These are the main complications soon after injury but in a severe head injury, as long as the patient remains unconscious, he is always at risk from inhalation or from pulmonary collapse due to immobility with subsequent bronchopneumonia.

Treatment

There are, therefore, several ways by which the chest may be implicated after head injury and the risks of such complications are very high. Fortunately, it is possible to prevent many of these complications and to treat others successfully by relatively simple measures. Thus, if the airway is not completely clear with the

patient in the ordinary side position, the semi-prone or "tonsil" position frequently proves effective. The position is changed 2-hourly. Suction apparatus should be available at the bedside so that secretions in the nose and mouth can be cleared with a soft rubber catheter. An ordinary airway is a valuable supplementary measure and allows the nurse more easily to remove secretions In addition, physiotherapy to the chest should be given twice a day so that the lung bases are fully expanded. If there is difficulty in clearing the upper respiratory tract, a short period of full postural drainage combined with physiotherapy with the foot of the bed elevated is invaluable. Although oxygen also may be given it has essentially a minor role and is no substitute for ensuring that the airway is kept unobstructed.

Tracheo-bronchial toilet

These measures suffice for the majority of patients in the early stages and for those who after some hours recover sufficiently to be moving by themselves and to have regained a good cough reflex, but in severer cases more may be required. If in the early hours after injury the airway is not entirely satisfactory, an endotracheal tube may be passed and through it the trachea and main bronchi cleared by suction, the tube then being removed—a tracheo-bronchial toilet—or the tube may be left in for a few hours until the progress of the patient can be more accurately assessed The danger of a retained endotracheal tube in these circumstances, however, has to be emphasized. The tube is inserted into an already damaged respiratory tract and if it is retained for long periods will certainly lead to a purulent tracheo-bronchitis and extensive ulceration As a general rule 12 hours is about the limit these tubes should be retained; in fact, well within that time it is usually possible to judge whether one is dealing with a patient who has received an essentially fatal brain injury or, alternatively, a severe brain injury from which recovery is possible and for which further measures to keep the airway clear may be required.

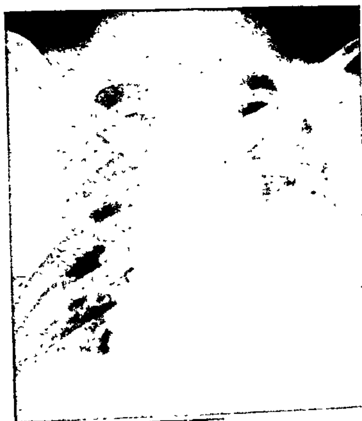
Tracheotomy

Experience with tracheotomy over the last 9 years has proved its value in selected cases (Echols and his colleagues, 1950; Lewin, 1953). It can be a life-saving procedure in patients in whom the airway cannot be easily maintained by the simpler measures enumerated above, but to be effective it should be performed early. It is useless to wait until the patient has already suffered further damage by respiratory embarrassment or already has a well-established chest infection This is not to say that it will not help such patients for, as Fig. 75 shows, bronchopneumonia may improve rapidly once free drainage and ready access to the main bronchi is achieved. However, the aim nowadays would be to prevent such a situation arising [illegible]

necessary, for there is a wide variation in a patient's individual response to a head injury and there have been many patients unconscious for weeks or even months, treated with simple nursing measures and without developing chest complications.

Indications

There are three groups of patients in whom tracheotomy should be considered:



(*a*)



(*b*)

FIG. 75.—Skiagrams taken: (*a*) 5 days before tracheotomy and (*b*) 8 days after tracheotomy, to show resolution of bronchopneumonia.

(*By courtesy of the Editor of Proceedings of the Royal Society of Medicine.*)

(1) Those in whom after some hours it is possible to assess as having sustained a severe head injury with the likelihood of their remaining comatose at least for some days, and in whom chest incidents are beginning to appear. There may be increasing secretion from the chest requiring frequent suction, or the secretions may become viscid and difficult to remove, signs of fluid in the lungs may develop on examination, or minor cyanotic episodes may be reported, particularly when the patient is turned These early signs should not be ignored because if the patient's unconscious state continues a major chest complication is almost inevitable, but a tracheotomy will provide a free airway and allow the ready removal of secretions in the trachea and main bronchi.

(2) Patients with other injuries which affect the airway. These are principally patients who, in addition to a major head injury with continued unconsciousness, have also a major jaw injury or a chest injury When the jaws are fractured there may be extensive bleeding into the pharynx and thence to the trachea, and in some instances a tracheotomy is the only way by which the airway may be safely maintained and at the same time allow the formal treatment and splintage of the jaws. Similarly, if there has been a major chest injury with haemothorax or pneumothorax or extensive contusion of the lungs, tracheotomy, by providing a free airway, can tip the scales in the patient's favour.

(3) Patients with a major head injury together with a fractured femur. This combined injury is always a difficult one to treat for the position and immobilization of the patient needed to secure adequate reduction of the femur is at variance with what is required for the patient's comatose state. Internal splintage to the femur is not the answer for these patients who are already gravely ill even without having to undergo a major operation, and in many instances now a tracheotomy has satisfied the requirements of the airway and allowed formal management of the fractured femur. Although the treatment of multiply-injured patients often calls for compromise, the effective treatment of the unconscious state must not militate, if possible, against good functional recovery from other injuries should the patient survive

Timing

In the latter two groups will be found those patients in whom a tracheotomy may be needed on admission, but in the first group which comprises the majority of patients likely to need tracheotomy the simpler measures are usually adequate for the first 12 hours, and it is usually at that time, or within 24 hours, that a decision for tracheotomy should in most instances be taken.

Operation

The operation of tracheotomy itself is simple (*British Surgical Practice*, Vol. 1, p. 154) and in these patients is conducted under local analgesia, often in the patient's bed. Complications are few but care must be taken to ensure haemostasis of the wound, and pneumothorax can occur if the tracheotomy is placed too low. Post-operatively, the inner tube is changed frequently and the trachea is sucked out with fine sterile catheters as required. To avoid drying and crusting of the tracheal mucosa a moistened gauze strip should be placed across the tracheotomy, or if available a humidifier can be used. Once a tracheotomy has been performed, there need be no haste to remove it and the author's usual practice is to retain it

until nasal feeding has stopped and the patient is able to swallow safely and easily by mouth, and the chest is clear. In adults there has been no complication from leaving the tube in for months if necessary and once removed it is surprising how quickly the stoma closes. In general the mistake would be to remove the tracheotomy too early rather than too late.

Tracheotomy in old age and in children

The indications for a tracheotomy are becoming well recognized, particularly in young adult life, but considerable judgment is required in advising its use at the extremes of life. Although old people may be carried through the acute phase of a severe head injury with its chest complications by its use, as accurate an assessment as possible should be made of the degree of recovery likely from the head injury, because in some instances it can only mean a long illness, distressing for the relatives and with no hope of a practical recovery. In young children there are particular complications of tracheotomy and, although there should be no hesitation in performing it if it is essential to the airway, the small size of the trachea and the sensitivity of the tracheal mucosa at this age makes a tracheitis with crusting and further obstruction a hazard. If it has to be done, a steam tent should be used from the beginning to ensure that the air is kept moist at all times, particularly in the early days until the respiratory tree is used to the changed circumstances.

Bronchoscopy

Bronchoscopy is indicated in certain circumstances, although nowadays it will almost always be in conjunction with a tracheotomy. From time to time a lobar collapse may occur and immediate bronchoscopy, which can be readily performed through the tracheotomy, may relieve the situation. This has been found to be particularly valuable in children where obstruction from a plug of mucus or crusting can so easily occur.

Antibiotics

Less reliance has been placed on antibiotics for chest complications in recent years since the mechanics of the airway have been better understood, and the increased frequency of antibiotic-resistant organisms has indicated their much more selective use. Culture of the tracheal secretions and the use of a short course of the appropriate antibiotic for a flare of pulmonary infection can be invaluable, but routine prophylactic use of antibiotics is being less favoured. The various problems associated with the severely injured patient often mean that for one reason or another a course of penicillin is prescribed in the early days for many cases, but the complications associated with the other antibiotics suggest that they should be used with discrimination.

NUTRITION AND METABOLIC DISORDERS

In many patients after head injury the duration of unconsciousness is relatively short so that within 24 hours, even though some are still confused, they have recovered sufficiently to swallow safely, and ordinary feeding by mouth can begin. In severe cases, however, it is necessary to begin artificial feeding and it is important to give adequate amounts of fluid and nourishment from the early days after injury. Studies of patients with severe head injuries have also shown that they may develop various metabolic disorders. Some, such as the uraemia of acute

renal failure, are usually fatal; others are associated with a high mortality if untreated, even in the absence of head injury, and may, if unrecognized, be important factors in the mortality rate from head injury. Indeed, it has been shown how prevention and correction of some of these disorders can play a part in lowering this rate (Higgins and his colleagues, 1954).

Intragastric feeding

Intragastric feeding is the method of choice, not only for its own natural advantages but because prolonged intravenous fluid replacement leads to problems of its own and may also increase the risks of the chest complications which it is so important to prevent. Save for very few patients it is possible to feed the unconscious patient for days, weeks, or months satisfactorily by an indwelling gastric tube.

As a general guide fluids, other than intravenous blood transfusion if required, are withheld during the first 12 hours. The majority of patients are adequately hydrated before injury and in these early hours vomiting may be common and gastric emptying and intestinal absorption may be delayed as a result of blood which has been swallowed, and probably also of central effects. Within this period operation may be needed and the stomach is best kept empty. During the next 12 hours, however, according to individual circumstances, tube feeding is begun with a small oesophageal tube, a Ryle's tube or a size 3 polythene tube fitted with a rubber end which is passed through the nose and into the stomach. Polythene tubing has the advantage of being a little easier to pass, and in patients who need tube feeding for long periods is less irritating than rubber. It does, however, tend to become brittle after some days and these tubes should be changed every 3 days, although the rubber tubes may be left *in situ* for about 5 days.

Fluid requirements

Fluid feeding is begun gradually after a few hourly aspirations have shown that the stomach is empty and that gastric dilatation is not taking place. The aim is to build up as quickly as possible an intake of 5 pints of fluid in 24 hours, consisting at the beginning of half milk and water to which glucose, 300 grammes, is added. This fluid is best given hourly at first in amounts of 2 ounces working up to about 8 ounces 2-hourly. If there is known to be increased fluid loss either from rapid breathing or a continued pyrexia about 100°F. the total amount is increased to 6 pints in 24 hours, and in those patients in whom it is known that the intracranial pressure is high the total amount may be reduced to 3½ or 4 pints for short periods. In the uncomplicated case additional salt should be added after the second day and a useful way of doing this is to substitute a pint of Ringer-Fisher solution for a pint of water. If coma continues it should be remembered that additional protein will be required, as these patients waste extremely rapidly and decubitus ulcers are likely to develop, particularly in older patients On the fourth day and thereafter eggs and protein foods are gradually added so that the daily intake of protein is raised at first to 100 grammes and later to 130 grammes. Vitamins are also added at this stage.

Control of nutritional requirements

Where a full biochemical service is available, estimations of the blood urea, plasma proteins, blood sugar and electrolytes, together with the urinary chloride,

protein and urea, are invaluable in judging what is required and also in recognizing and correcting the various metabolic disorders described below. In many cases, however, a few simple routine investigations will suffice and also indicate those patients in whom a more formal biochemical investigation should be made. Thus, the urinary output should be measured daily and, although this is difficult to maintain when the patient is incontinent, a measure check for 4-6 hours daily together with the nurses' estimation of urinary output can give a useful working guide. Each day the urine should be examined for sugar and albumin, the specific gravity taken and the chloride excretion measured by the Fantus test. This last test is, however, unreliable and should be used only if an accurate estimation of urinary chloride cannot be made. A blood urea estimation should be made on the second day and thereafter as often as seems necessary. It is unwise to start high-protein feeds if the blood urea is above 60 milligrams per 100 millilitres. Where the urinary output is unsatisfactory, or abnormalities are discovered, or if the urinary chloride estimation falls below 1 gramme per litre (measured as NaCl), or rises above 4 grammes per litre, then a fuller biochemical investigation of blood and urine is indicated. The reader is also referred to the articles on "Fluid and Electrolyte Balance" (*British Surgical Practice, Surgical Progress*, 1953, p. 91, and also the present volume, p 47)

Metabolic Disorders

Metabolic disorders may arise, many of which are transient, such as temporary proteinuria or glycosuria, but some of which are more serious. In a series of 76 patients with severe head injury transient disorders occurred in 66 per cent and the major disorders in 24 per cent, the latter group having a mortality rate of 61 per cent.

Water deprivation

The commonest disturbance, water deprivation, usually arises from a reluctance to begin artificial feeding in the unconscious patient, the decision being delayed in the hope that the patient may soon regain consciousness sufficient to swallow. It is not uncommon to see patients who have been given only a few ounces of fluid during the first few days after injury. Difficulties in retaining the feeding tube or in securing adequate absorption of fluids through the intestine are further problems which arise from time to time. Water deprivation may also be precipitated by increased fluid loss from rapid breathing and when there is pyrexia. It can also occur where there is an unrecognized diabetes insipidus. Another factor is the policy, at one time popular, of treating head injuries deliberately by dehydration, on the assumption that oedema of the brain together with raised intracranial pressure was a common accompaniment of head injury, and that this was best countered by a regime of a limited fluid intake, in some instances reinforced by the administration of hypertonic rectal enemas and frequent lumbar punctures. Although it is true that there are some patients whose intracranial pressure is known to be high and for whom such a regime carefully controlled by biochemical studies and for a limited time may be of value, routine dehydration for head injury is certainly unnecessary and potentially dangerous and usually

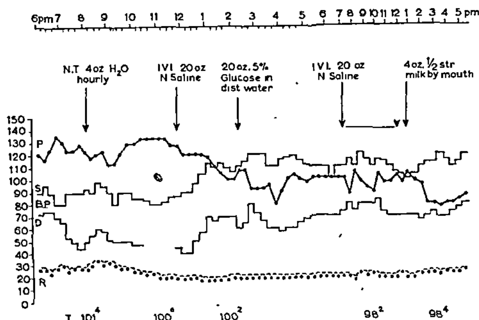


FIG 76.—Observation chart to show the effects of dehydration. The temperature and the rapid pulse fall and the blood pressure rises as rehydration proceeds.

does far more harm than good. Water dehydration can lead to worsening of the patient's general condition and also to a deterioration in his conscious level, thus leading to an erroneous diagnosis of cerebral compression Figure 76 illustrates the chart of one such patient who was transferred to a neurosurgical unit on this supposition, but the clinical and biochemical evidence of dehydration together with the absence of localizing signs and the brisk and equally reacting pupils indicated the true diagnosis. Replacement of fluid was quickly followed by improvement in the patient's general condition and also the conscious state.

Diabetes insipidus

This is an uncommon complication, but does arise particularly in patients who have received a severe frontal or occipital injury (Porter and Miller, 1948). Diabetes insipidus follows hypothalamic damage and in the early days after injury there is usually sufficient antidiuretic hormone to prevent the syndrome developing, the commonest time of onset being about the tenth day. In the conscious patient it is declared by polydipsia and polyuria and can be readily checked by measuring the specific gravity of the urine which is usually found to be below 1006. If the patient is unconscious, however, the diagnosis may be missed If there is a suspicion of increased secretion of urine the specific gravity of the urine should be checked. Fortunately, in the majority of cases the condition is mild and temporary and it is sufficient to increase the patient's fluid intake. In more severe cases Pitressin, either as snuff or by injection, is indicated.

Respiratory alkalosis

Where there has been severe diffuse brain injury accompanied by prolonged periods of hyperpnoea and decerebration respiratory alkalosis may arise, and on examination the patient is found to have a low plasma-bicarbonate level and an alkaline urine. In some instances the hyperactivity of the respiratory centre may be reduced by intramuscular phenobarbitone, but more recently many of the patients in this group have been treated with hypothermia (*see* below) which has quietened the respiration rate and reduced the muscular hyperactivity.

Diabetes mellitus

Although transient glycosuria without hyperglycaemia is not uncommon, a true hyperglycaemia with glycosuria has been seen in a few patients. Whether it is entirely related to the head injury or merely that the injury has brought to light a previously undiagnosed diabetes mellitus is not yet certain, but in either event the appropriate dietary treatment of diabetes is called for and insulin may be needed. The condition usually recovers spontaneously after a variable period of time, and unless this is detected by 4-hourly urinary sugar tests insulin coma may occur.

Disturbance of sodium and chloride balance

Inability to excrete the chloride ion with resultant hyperchloraemia and hypochloruria and its reverse, the excessive loss of chloride ion with hypochloraemia and hyperchloruria, are well-recognized disturbances in a variety of conditions, but their frequency after head injury has been recognized only in recent years (Higgins and his colleagues, 1951). The high mortality which attends these disorders in other conditions and the similar result after head injury if the imbalance cannot be corrected leave little doubt that they can be important factors in the mortality rate. For these reasons the chloride excretion in the urine together with, if possible, blood estimations need to be performed regularly after severe head injury and are essential should any deviation from normal become apparent. The syndrome of hyperchloraemia can be reversed in some cases by omitting sodium chloride from the diet and increasing the fluid intake. The syndrome develops in the early days and is usually declared by about the fifth day; it has occurred in all age groups. On the other hand, excessive loss of sodium and chloride ions in the urine with the accompanying clinical features of dehydration arises later and usually after the first week, and seems confined to older patients. Of 5 patients seen with this syndrome in a series of severe head injuries all were over 60 years. Once recognized, a high sodium chloride intake is required, and although this produces improvement in the signs of dehydration the subsequent course of the disorder is unpredictable and may continue for some time. Attempts to reverse the progress by Eucortone and deoxycortone acetate and cortisone have so far not proved successful.

Renal uraemia

Acute renal failure with tubular necrosis may follow head injury and is associated with a high mortality rate. The signs of renal damage are witnessed by oliguria, proteinuria, a low urinary specific gravity and a rising blood urea level. If treatment is to be effective at all it has to be begun early, and Taylor (1957) has indicated that from a practical point of view patients who show a blood urea

level higher than 100 milligrams per cent together with urine urea levels below 2 grammes per cent should be considered as having a degree of renal failure, and corrective treatment should begin. This implies restriction of the fluid intake to balance loss and the provision of a high-calorie non-protein diet. This may be achieved by a 10 per cent or in some cases a 20 per cent glucose solution via the gastric tube. Where absorption has failed in association with the uraemic state similar intravenous therapy using a polythene catheter has been tried although the risks of thrombosis are considerable. It is possible that some of the early cases may be reversed by such simple measures but in more established cases the best hope for the future would seem to lie with the early use of an artificial kidney, for the katabolic break-down of protein following trauma causes fatal uraemia 6–8 days before diuresis can occur.

Weight changes

Excessive loss or gain of weight may occur in the later stages after severe head injury and may also be mentioned briefly here. Early loss of weight is common but in some patients, particularly where the unconscious state is prolonged into weeks, wasting may be profound and continued despite a high protein and apparently adequate dietary replacement. It is seen especially in older people, and extreme inanition with decubitus ulceration may result.

The reverse condition, that of obesity, develops not uncommonly in younger patients who have recovered from a major head injury, and is probably related to injuries in the region of the hypothalamus During convalescence the appetite may become excessive (bulaemia) and lead to a gross increase of weight Fortunately, in many cases it seems to be self-limiting and after some months the weight increase stops; some of these patients when seen years later have lost weight again, although they have not returned to their pre-accident habitus Simple dietary advice in the early convalescent period can mitigate this development to some extent, and this is certainly important where defects of locomotion such as ataxy and hemiplegia are present as the obesity then proves an added handicap.

Relation of Metabolic Disorders to Brain Injury

Although it is not proposed to discuss this problem in detail at this juncture, there is increasing evidence that some at least of these metabolic disorders are primarily related to the brain injury and not necessarily to the various secondary complications which may attend the unconscious state Similar metabolic disturbances have been described following cerebral tumour, cerebrovascular disease and leucotomy In the experimental field the production of diabetes mellitus and diabetes insipidus from focal brain lesions is well known; lesions in the hypothalamus have produced sodium and chloride ion disturbances, and stimulation of the cerebral cortex, renal cortical ischaemia In severe head injuries lesions in the hypothalamic and posterior orbital cortex regions are common. Much more needs to be known of the neural pathways involved, but there are now cogent arguments from various fields to relate metabolic disorders to focal brain lesions.

HYPOTHERMIA

The need to control the temperature of the unconscious patient following head injury has already been mentioned, and this essential part of routine nursing care

should be distinguished sharply from the treatment of selected cases by hypothermia, a method which is still undergoing trial. The reader is referred to *British Surgical Practice, Surgical Progress*, 1956, p. 177, for a description of the principles, and some of the physiological effects of hypothermia.

Effects

The possible beneficial effects of hypothermia in severe head injury are immediately apparent. Thus, as the temperature falls the increased respiratory rate and the excessive bronchial secretions which are present in some of the patients diminish and improve the airway. Muscular tone also decreases. In severe head injuries accompanied by gross extensor spasm with decerebration, which also affects the pharyngeal and laryngeal muscles and further embarrasses the airway, it can readily be demonstrated that as the temperature falls the frequency and severity of the decerebrate attacks, which can be fatal and which also lead to a considerable increase of body metabolism, lessen. With the quietening of the excessive respiratory and muscular activity the risks of metabolic disorders, such as dehydration and alkalosis, are much less, and it may also be anticipated that the lowered metabolism of the body generally would decrease the excessive protein break-down and the early wasting which so many of these patients show. The use of hypothermia in neurosurgery, particularly for aneurysms and vascular brain tumours, has also shown that as the temperature falls so does the intracranial pressure. This would be an advantage where cerebral oedema has led to a considerable rise of intracranial pressure after head injury. Finally, experimental work has shown that the oxygen requirements of the brain fall with the temperature. The considerable risks of hypoxia which exist in patients with severe head injuries have been sufficiently emphasized already, and it is hoped that with the use of hypothermia it may be possible to conserve damaged but recoverable brain tissue or brain embarrassed by surrounding oedema and thereby improve the chances of ultimate recovery.

Indications

For all these reasons, therefore, hypothermia would seem worthy of trial, bu at the most it is a supportive measure only and is unnecessary in the management of the majority of cases. Encouraging results have been seen in patients with severe diffuse brain injury with coma, decerebration and hyperpnoea, and to a lesser extent in patients suffering from cerebral compression, either from severe cerebral oedema or, more commonly, from extensive contusion and laceration of the brain, particularly at the frontal and temporal poles. Most of the patients in this latter group have had a craniotomy and decompression performed, but where this is not completely effective the added hypothermia may prove an advantage, although it should be remembered that one is dealing in this group with the severest of injuries and the mortality is always likely to remain high.

Temperature levels

In general most of the advantages from hypothermia have been seen when levels of about 95°F. (35°C.) have been reached with a lower limit in some of 90°F. (30°C.) and this temperature can be maintained for an average period of 6 days. Most of the complications of hypothermia, particularly to the myocardium, are

seen at temperatures below this, and there would therefore seem to be little justification in the present state of our knowledge for seeking lower levels, particularly where one wishes to maintain the hypothermia for several days. Moreover, these temperatures can be reached by relatively simple measures.

Technique

The patient is nursed in a room where the windows are opened, and if necessary fans are used. He is covered by a single sheet. Ice bags are applied to the skin and in most patients the desired temperature level can be reached within a few hours. To assist cooling, chlorpromazine (Largactil), in doses of 25–50 milligrams intramuscularly, is given 4-hourly and if the response is unsatisfactory promethazine (Phenergan), 25 milligrams intramuscularly, can be added as required. Once the desired temperature level is reached it is usually easy to maintain it with occasional doses of the drugs mentioned and periodic reapplication of the ice bags should the temperature tend to rise. Although chlorpromazine is used mainly as a vasodilator to aid cooling there is evidence that it has a direct action in lessening muscle spasticity and also that it may inhibit the activity of the reticular substance in the brain-stem. Its use as a mild sedative for restlessness has already been mentioned, and of the many drugs that have been used to aid hypothermia, chlorpromazine seems to be the most appropriate one in head injury. During hypothermia the fluid requirements of the patient fall; for the adult an intake of 3–3½ pints every 24 hours is usually sufficient.

The beneficial effects of hypothermia on the respiration rate and airway have already been mentioned, and the change from embarrassed and rapid breathing to a quiet tranquil state under hypothermia is often striking Metabolic disorders seem to be prevented rather than produced with this method, but it should be mentioned that in some patients where cooling is rapid this may temporarily interfere with gastric and intestinal function, and in this event intravenous fluid has to be given during the early period of hypothermia

Complications

As the use of hypothermia is limited to very select cases it means that in most instances cerebral compression by oedema or clot has already been treated by operation or excluded by exploratory burr-holes. There is nothing to suggest that hypothermia is an alternative for a craniotomy, where this is indicated, indeed, if the method is used one has to be particularly vigilant in noting any changes in the patient's condition which would suggest continuing cerebral compression and the need for operation Similarly, the usual reactions to infection, whether of the meninges or of the chest, may be masked under hypother [illegible]

[illegible]

The proper place of hypothermia in head injury has still to be determined, but the results so far in the groups mentioned suggest that it may prove a useful adjunct in some severe head injuries (Laborit and Huguenard, 1951; Sedzimir, 1956; Lewin, 1957).

CEREBRAL COMPRESSION

The general management of the unconscious patient has been described in some detail since these principles affect all patients who have sustained a major head

injury, and it has perhaps been insufficiently stressed in the past what a considerable part the treatment of the many factors involved can play in lowering the overall mortality. The need to diagnose the onset of cerebral compression at the earliest opportunity and to relieve it surgically is well recognized, even though this affects only a small proportion of patients in any large series of head injuries. Untreated, cerebral compression is usually fatal, but it must be confessed that the mortality of treated cases still remains uncomfortably high and the reasons for this are not hard to find. Extradural haematoma, for example, although a well-known complication, is a comparatively uncommon one and not infrequently by the time the diagnosis is made with accuracy and the clot removed the patient has already suffered irreversible brain-stem compression. A chronic subdural haematoma may be evacuated simply by burr-hole exploration with a very satisfactory result, but an acute subdural haematoma is usually secondary to severe brain contusion and laceration, and removal of the surface clot may deal with only part of the problem; the contusion and oedema resulting from the brain injury itself may also give rise to cerebral compression and demand a more formal decompression. The following notes on cerebral compression should be read in conjunction with the management of cerebral compression already described (*British Surgical Practice*, Vol. 2, p 349).

Extradural haematoma

Delay in operation still remains the main factor in the mortality rate and there are few surgical emergencies where the time factor is so important. Valuable as the pupillary changes are, it should be realized that a fixed and dilated pupil is a sign of severe brain-stem compression and the aim should be to diagnose many of these cases at a stage when the pupils are equal and reacting. A lucid interval is extremely valuable, but attention to less obvious changes in the patient's conscious level, to alterations in the patient's physiological state, and to the appearance of fresh neurological abnormalities as outlined above, may all help to make an earlier diagnosis Where to explore is as important as the decision to operate, for the teaching that a temporal burr-hole is necessarily the correct exploratory site leads to many of these clots being missed.

Atypical sites

Although it is true that the majority of extradural haematomas occur in the temporal region in association with tearing of the middle meningeal arteries or veins, it should be remembered that 30 per cent of extradural clots occur in other sites, frontal, parietal and cerebellar (Lewin, 1949) No exploration for an extradural haematoma is complete unless an exploratory burr-hole has been made in relation to the site of scalp bruising and laceration and the position of a fracture line when present. Planning of the operation, after the whole scalp has been shaved and the scalp carefully inspected together with the radiological films, is invaluable. Figure 77 illustrates the findings in one patient who presented with the symptoms and signs of cerebral compression after a lucid interval and with bruising around the right eye. Exploratory burr-holes in the usual sites both in the right frontal and right temporal regions were negative, the brain being tight in these positions. At autopsy a massive extradural clot lying almost entirely beneath the frontal lobe was disclosed; this would have been detected by a more anterior frontal exploration.



Fig. 78.—Fracture of the right occipital bone in a case of posterior fossa extradural haematoma.

condition soon after the accident has been reasonably satisfactory the advantages of a formal bone flap and decompression should be borne in mind. The side for the exploration is usually clear after the initial burr-hole exploration, and a fronto-temporal flap which exposes both frontal and temporal poles is the common one required. In some instances pulped and contused brain substance can be sucked out with considerable relief of the compression. This is, of course, major surgery and all the immediate circumstances have to be borne in mind, but there is little doubt that such operations can help some of these gravely injured patients.

Intracerebral haematoma

Quite apart from intracerebral haemorrhage which may occur secondary to a head injury in older people, associated with hypertension and atherosclerosis, true traumatic intracerebral clots may arise at all ages and give rise to the symptoms and signs of cerebral compression. They may measure 5 centimetres or more in diameter and the fronto-temporal region is the commonest site for their occurrence. Their evolution tends to be slower than with the acute surface clots and to lead more often to accurate localizing signs. Angiography has led to the detection of several of these cases (Fig. 79) and the evacuation of these clots through a cortical incision usually leads to a satisfactory result.

Other causes of cerebral compression

In addition to massive haematomas, cerebral oedema alone, particularly in younger people, or focal cerebral oedema associated with severe contusion and



(*a*)



(*b*)

FIG 79.—(*a*) Lateral and (*b*) left antero-posterior angiogram in a young boy with cerebral compression after a head injury shows a displacement of the anterior cerebral vessels to the right side and *elevation of the left middle* cerebral vessels At operation a large intracerebral haematoma in the left temporal lobe was evacuated.

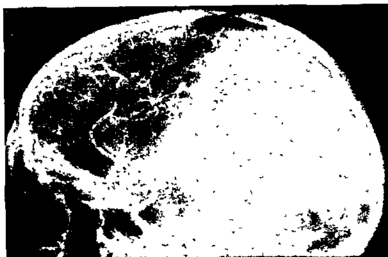
laceration, particularly at the frontal and temporal poles, may from time to time give rise to cerebral compression and require operation. Craniotomy followed by opening of the dura and removal of the pulped brain can be very effective, but bone flaps for massive generalized cerebral oedema are rarely effective, and where help is most required it is usually impossible to open the dura because of the tightness of the brain underneath. Hypertonic solutions such as intravenous sucrose 50 per cent, or better still triple or quadruple strength human plasma, may help, and there is some evidence to suggest that in this group hypothermia may find a useful place.

CEREBROVASCULAR COMPLICATIONS

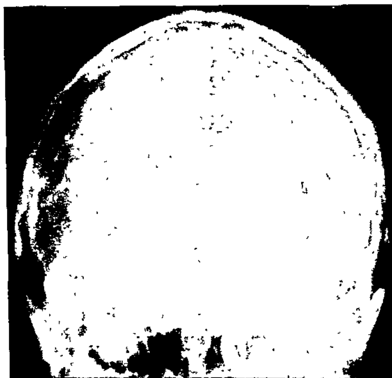
The development of cerebral angiography over the last 10 years has led to the detection of other complications following head injury which in the past were confused with intracranial haematoma. It has already been indicated that this investigation has a very limited place in the early stages after head injury where if cerebral compression is suspected exploration should be immediate; time should not be lost in special investigations which may not be easy to arrange at short notice and which at this particular stage may be misleading. At a later stage, however, angiography has proved invaluable in the management of head injuries and allows a more accurate diagnosis of the several complications that may be seen during the first week.

Carotid artery thrombosis

Traumatic thrombosis of the internal carotid artery or of its branches, particularly the middle cerebral artery, may arise after head injury, at all ages and in patients without any other evidence of vascular disease (Sedzimir, 1955). Thrombosis of the internal carotid artery may give rise to gross hemisphere signs with contralateral hemiplegia and hemianaesthesia, and this diagnosis should be entertained where these signs are present in a patient who otherwise seems to have sustained only a minor head injury. In other cases, due to an adequate collateral circulation, such gross signs are not in evidence, but mild hemisphere signs together with continued confusion may lead to angiography to exclude an intracerebral clot with the disclosure of an internal carotid thrombosis. Bruising of the neck or other evidence of local injury may be present in some cases, and in the author's experience many of the cases after head injury are associated with fractures of the facial skeleton. On more than one occasion the appearance of gross hemisphere signs shortly after a head injury has suggested a diagnosis of intracranial clot; but retention of full consciousness together with normally reacting pupils has indicated the true diagnosis of an arterial thrombosis, later confirmed by angiography (Fig 80). In most cases there is no rise of intracranial pressure, but from time to time extensive infarction of the affected hemisphere with the surrounding inflammatory response and oedema leads to a phase of raised intracranial pressure with drowsiness and papilloedema, and in these cases a certain diagnosis from an associated intracranial clot is usually not possible without exploration. Sympathetic blocks and vasodilators have not proved very effective in the treatment of arterial thrombosis, and the most important point in their management in the early stages is to ensure that the blood pressure is maintained. The importance of this can be gauged from other patients with head injury associated with severe multiple



(*a*)



(*b*)

FIG. 80.—(*a*) Lateral and (*b*) antero-posterior angiograms to show thrombosis of the left middle cerebral artery after head injury in an otherwise healthy man, with consequent severe left hemisphere disability. Note the absence of filling of the middle cerebral vessels.

injuries; should the blood pressure fall for any reason, cerebral ischaemia may result and in the presence of a recent head injury lead to transient hemiplegias or to permanent disability.

Venous thrombosis

Thrombosis of the main venous sinuses, mainly the sagittal and lateral sinuses, may occur after head injury and give rise to characteristic clinical syndromes. A fracture is often present in relation to the affected sinus, and the common clinical picture is a delayed onset of headache, papilloedema and cranial sixth nerve palsies due to external hydrocephalus following the thrombosis (Foley, 1955; Martin, 1955) Less often fractures opening up the sagittal suture may lead to extradural bleeding and thrombosis of draining veins with a syndrome characterized by papilloedema, spasticity and weakness of the legs, bilateral ankle clonus and bilateral extensor responses. Fortunately, in both these instances the condition usually subsides quietly and may be helped during the acute phase by mild dehydration Carotico-cavernous aneurysms may also follow head injury.

MULTIPLE INJURIES

Present-day road accidents mean that in many cases the patient receives injuries to other parts of his body in addition to his head injury; in an unselected series it was shown that over 30 per cent of patients admitted with head injury sustained other injuries as well. Many of these are fractures, but major chest injuries, abdominal injuries, such as rupture of the liver and spleen, and fractures of the spine with and without spinal cord involvement, are all seen. Although many are easy to diagnose, others are too easily missed in the circumstances of an unconscious patient. Injuries to the chest and abdomen and spine are particula prone to be overlooked.

Chest injuries

Re-examination for a possible chest injury, together with radiography if necessary, should always be made if there is difficulty with the breathing which cannot be readily explained or which is not correctable by the ordinary measures described.

Abdominal injuries

The presence of shock should always direct attention to the abdomen, and it is wise not to ascribe shock to a head injury in the absence of external bleeding until there has been a full re-examination of the patient to exclude other injuries. Unless patients are deeply comatose it is often possible, by watching their responses, to detect tenderness in the abdomen, and routine auscultation of the abdomen for the presence or absence of bowel sounds and the amounts of stomach aspirates are also valuable pointers At times the signs of the abdominal complications may be delayed, and although with the onset of severe shock from intraperitoneal bleeding the patient's conscious level will fall and a previously stuporose patient will become comatose, until a very late stage the pupils may remain equal and reacting. This was so in a patient with a delayed rupture of the spleen who on the fifth day suddenly went into severe shock (Fig. 81).

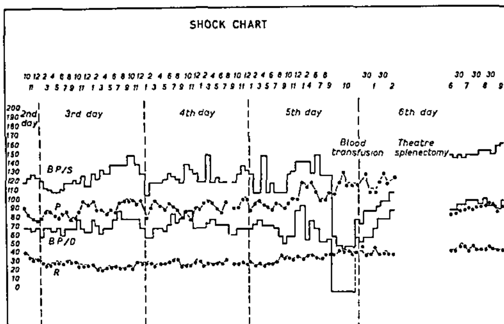


FIG 81 —Observation chart in a patient unconscious from a major head injury who on the fifth day collapsed from delayed rupture of the spleen The blood pressure was unrecordable for a short period and the patient became more deeply unconscious, but the pupils remained equal and reacting

Spinal column injuries

Spinal column injuries also present difficulties and in particular injuries to the cervical spine are not uncommonly associated with head injury. Local tenderness is always suggestive and the neck rigidity from meningism can usually be distinguished from that resulting from injury in that the former usually limits movement in flexion only, whereas after a neck injury there is pain and limitation of movement in lateral rotation as well. As the routine management of the unconscious patient necessitates frequent turning, it is important to make a radiological study of the neck beforehand in all doubtful cases before arranging further management.

Spinal cord injury

In a patient already comatose with a head injury a spinal cord injury may be suspected where there is gross disparity in the movements of legs as compared with the arms on painful stimulation, if the reflexes are absent, which is uncommon after head injury except in the terminal stages; and if there is retention of urine, which does occur after head injury but is the exception to the general rule of incontinence. There may also be a suggestion of a sensory level to pinprick or the absence of sweating below the level of the lesion may be noted

Management

The management of patients with multiple injuries calls for compromise. Although, with the exception of haemorrhage, the management of the head injury

usually takes precedence in the early hours because of the immediate factors which are involved and which may prove fatal, one should not accept unnecessary delay in the treatment of other injuries merely on the grounds that the patient has had a head injury, for this may delay recovery from shock and increase the risks of infection. Moreover, if a patient is likely to be disabled as a result of his head injury, the full functional capacity of his limbs becomes even more important, and in practice it is found that in most cases effective management of the fractures and other injuries can be conducted *pari passu* with the essential management of the head injury. Certainly the correct order of priorities plays an important part in lowering the mortality of this group.

RESULTS

The increased attention paid to the many factors associated with the mortality after acute head injury is undoubtedly leading to very much improved results. The better appreciation of the problem of cerebral compression, the development of ancillary aids to diagnosis, such as angiography, and the improved distribution of neurosurgical services throughout the country are doing much to improve the surgical results of the operable group. But as much help is coming from the realization that the mortality rate is also associated with extracranial factors, such as chest complications and metabolic disorders, and the special problems arising in the treatment of the multiple injured patient.

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PROGRESS IN NEUROSURGERY

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INTRACRANIAL TUMOURS

Methods of investigation

Recent advances in the management of intracranial lesions treatable by surgery have been made possible largely by improved methods of radiological investigation. Cerebral angiography has been used more widely and the need for ventriculography has decreased (Dimant, Moxon and Lewtas, 1956), but the value of plain radiographs of the skull remains undiminished (Griffiths, 1957). Angiography has the advantage over ventriculography that it can be employed in cases of cerebral tumour with high intracranial pressure without upsetting the fine balance of intracranial tension, so that operation to relieve the condition is not as a rule necessary on the same day.

Carotid angiography

The technique of carotid angiography has been improved and it is now nearly always performed by the subcutaneous method, very rarely by open exposure of the vessel. It has become a relatively safe procedure so that Bull (1950) has been able to record only 3 deaths in over 1,000 cases, but it should be performed with great caution in elderly hypertensive patients (Crawford, 1956). The commonest complication is haematoma of the neck although this rarely causes respiratory embarrassment severe enough to necessitate evacuation Increase in abnormal neurological signs occurs very rarely owing to thrombosis of the common or internal carotid artery, but sometimes owing to cerebral oedema, particularly in cases of glioma with high intracranial pressure. The investigation may be performed under local analgesia or general anaesthesia Films to show the arterial, capillary, and venous phases of the angiogram are necessary and, in most centres, these are obtained by manually changing cassettes, although special apparatus for automatic serial angiography is available.

Changes in the normal angiographic appearances may be visible in different phases of the angiogram The main branches of the anterior or middle cerebral arteries may be displaced to indicate the approximate site of the lesion, but smaller vessels in different phases of the angiogram may be seen to be stretched about part of the circumference of the tumour and so indicate its exact site. This is seen commonly with meningiomas and cysts. In the venous phases displacement of deep veins across the mid-line usually indicates a deeply seated intrinsic tumour.

Often tumours show a definite blush and by this means it is possible to diagnose the pathological type of the tumour. Glioblastoma multiforme is shown characteristically by an *irregular mass* of vessels of uneven calibre with small arteriovenous shunts (Fig. 82) (Schiefer, Tönnis and Udvarhelyi, 1954; Udvarhelyi, Walter and Schiefer, 1954). When such a vascular arrangement is seen clearly, it is possible to diagnose *glioblastoma* with certainty, and Zülch (1958) has said



FIG 82 —Glioblastoma multiforme in the fronto-parietal region The capillary phase of an angiogram showing characteristic tumour circulation composed of vessels of irregular calibre with arteriovenous shunts and early filling of the draining veins.

that when these radiographic characteristics have been present and histological examination has been carried out subsequently, the diagnosis of glioblastoma has always been confirmed. Meningiomas are often clearly shown by a well-defined blush composed of a fine meshwork of capillaries sometimes fed by meningeal vessels (Fig. 83*a* and *b*). *Circular shadows are seen sometimes in abscesses*, owing to the new formed vessels about them. Hydrocephalus from any cause produces a [illegible] cerebral artery as it curves over the

Craniotomy

When it is not possible from the angiogram to be certain of the nature of the space-occupying lesion, craniotomy in the majority of cases *is preferable to* aspiration biopsy for diagnosis. Needle biopsy through a burr-hole was a common



(*a*)



(*b*)

[illegible]

the circumference of the tumour.

necessity when air studies were the main radiographic means of diagnosing supratentorial tumours, for ventriculography and air encephalography rarely give an indication of the pathological type of a tumour except by its location. The lessening in the need for aspiration biopsy has been a considerable advance since its results are often uncertain and, in cases of high intracranial pressure, it often produces a marked change for the worse.



FIG 84.—Chronic subdural haematoma. Arterial phase of an angiogram (antero-posterior view) showing characteristic displacement of cortical vessels away from the inner table of the skull. The anterior cerebral artery is also displaced across the mid-line.

Ventriculography and air encephalography

Ventriculography and air encephalography still play a very useful part in the diagnosis of intracranial lesions. In air encephalography there has been a growing tendency to use less air and it is usually unnecessary to inject more than 50 millilitres. In cases suspected of supratentorial tumour, air studies are indicated when angiography has failed to reveal the lesion. This may occur particularly with tumours growing in areas difficult to investigate angiographically, such as the occipital, posterior parietal, and posterior temporal regions; with tumours which tend to replace rather than displace brain tissue; and with tumours lying within or largely within the ventricles.

Positive contrast ventriculography

For the investigation of tumours lying in the posterior fossa and for lesions involving the aqueduct of Sylvius and third ventricle, ventriculography or air encephalography are still the special radiological investigations of choice, but positive contrast ventriculography is now often employed. The substance used is ethyl iodophenylundecylate (Myodil); a markedly radio-opaque liquid, heavier than cerebrospinal fluid, which demonstrates the narrow channels more clearly than air Myodil, 1–1·5 millilitres, is instilled into one of the lateral ventricles



Fig. 85.—Medulloblastoma in the fourth ventricle. Myodil ventriculogram showing Myodil lying in the mid-line in the posterior end of the third ventricle and aqueduct of Sylvius In the fourth ventricle Myodil is displaced towards the left side by the tumour

through a frontal or posterior parietal burr-hole and the head is then manipulated blindly or with radiological screening so that the Myodil passes into the third ventricle, aqueduct of Sylvius, fourth ventricle, and cisterna magna By this means this narrow part of the ventricular system can be seen clearly on radiographs and any deformity or blockage can be demonstrated (Johnson, 1953) (Fig. 85). In antero-posterior views these cavities normally lie in the mid-line; in lateral views the aqueduct should lie at approximately the junction of the anterior and middle thirds of a line drawn from the dorsum sellae through the aqueduct to the inner surface of the skull (Lysholm's line), and (Fig 86) the fourth ventricle should lie at approximately the mid-point of a line drawn between the tuberculum sellae



FIG. 86.—Astrocytoma in the upper part of the cerebellar vermis. Myodil is seen filling the posterior end of the third ventricle, aqueduct and fourth ventricle. Lysholm's and Twining's lines are shown. The aqueduct is displaced slightly forwards. Some Myodil remains in the posterior horn of a lateral ventricle.

and the internal occipital protuberance (Twining's line) (Sutton, 1952). When intracranial tension is raised the small amount of Myodil used tends to be much less upsetting to patients than the injection of large quantities of air, but, owing to the possibility of ependymitis, it is important that all Myodil should be manipulated out of the ventricular system and into the subarachnoid space before operation, or afterwards should operation prove necessary to overcome a complete block.

Lumbar air encephalography

Recently in Sweden and Germany there has been a tendency to make use of lumbar air encephalography even when the intracranial tension is known to be high, and it is claimed that tumours lying in the pontocerebellar angle can actually be outlined in that way (Dressler and Albrecht, 1956; Norlén and Wickbom, 1958). However, in such cases this means of investigation has not been accepted by most neurosurgeons in Great Britain, and even lumbar puncture is still considered to be contra-indicated owing to the danger of provoking a pressure cone.

Vertebral angiography

Vertebral angiography, though more hazardous than carotid angiography, is becoming more widely used but is of little help in the diagnosis of tumours in the

posterior fossa, except in differentiating between pontine gliomas and prepontine tumours such as meningiomas and trigeminal neuromas (Radner, 1951). In the [illegible] fully by operation (Logue, 1958).

Radioactive isotopes

The use of radioactive isotopes in the diagnosis of intracranial tumours is increasing in some centres, particularly in North America. It has the advantage that it can be employed with little upset to the patient and its accuracy in routine use in the localization of tumours is now claimed as 65–75 per cent (French and Chou, 1957; Rhody and Nowlis, 1957). It appears yet to be of little value in the diagnosis of deeply seated tumours in the cerebral hemispheres, mid-brain, and posterior fossa, and it has the disadvantage that it merely localizes the lesion in relation to the head and gives no indication of its type. However, it may prove to be a valuable method of investigation.

Treatment

Improvements in the methods of investigation of brain tumours have on the whole allowed patients with high intracranial pressure to be brought to the operating theatre in better condition Formerly it was not an uncommon necessity for ill patients to have to undergo ventriculography and aspiration biopsy as preliminary investigations on the same day as craniotomy for removal of the tumour. With the wider use of angiography, except when ventriculography is indicated, it is now usual for patients to have their tumours diagnosed and accurately located some days before operation.

In the pre-emergency phase caffeine sodium benzoate has proved to be of value in reducing headache and drowsiness. It has the advantage over magnesium sulphate enemas that it can be given intramuscularly or, less effectively, by mouth. The adult dose is 0 5 gramme (7½ grains) 6-hourly. It has no toxic effects in this dosage, but care should be taken that patients do not become dehydrated By its use it is often possible to delay the need for operation, so that the patient can be brought to the best possible condition and investigations can be completed.

Controlled arterial hypotension

Controlled arterial hypotension has been used to reduce the tendency to haemorrhage during operation upon unduly vascular tumours and vascular abnormalities such as aneurysms and angiomas (Stephen and his colleagues, 1956). It also tends to reduce intracranial tension so that the brain has less tendency to herniate through the dural opening and the need for retraction is reduced It has the disadvantage that should severe haemorrhage occur the ill-effects of this are accentuated, and it is therefore necessary that blood lost should be replaced immediately.

Artificial hibernation

Artificial hibernation has been employed particularly in operations upon intracranial aneurysms and angiomas, and its use has sometimes been extended

to the treatment of tumours (Burrows and his colleagues, 1956; Inglis and Turner, 1957). The latter, however, seems hardly justified in most cases and may introduce an additional unnecessary risk. In operations on the vascular tree it is of undoubted value in selected cases, for metabolism of the brain is so reduced that main arteries may be temporarily occluded without ill-effect for some minutes. By this means, when necessary, it may sometimes be possible to deal with a vascular lesion in an almost bloodless field (Botterell and his colleagues, 1956).

Artificial hibernation has also been advocated in the treatment of patients suffering from the acute effects of severe head injuries and spontaneous intracranial haemorrhage, but its value in the treatment of these conditions, except in so far as it prevents hyperthermia, has yet to be generally accepted.

Technique of operating

The technique of operating has shown little tendency to change except that the sitting position is now widely used for lesions involving the posterior fossa and cervical spine. A special operating chair is usually employed and the patient's head is fixed to an anterior head-rest. The position has the advantage that, by improving venous return, venous bleeding is reduced and intracranial tension is lowered. These factors facilitate the approach to lesions lying in relatively inaccessible positions, such as the anterior aspect of the cerebellum and brain stem, or the interior of the fourth ventricle The position has the disadvantage that there is a considerable risk of air embolism, but this can be overcome by meticulous and immediate control of haemorrhage In addition, during the approach to the dura mater, the jugular veins in the neck should be gently compressed at frequent intervals to show up any veins which may have been divided unnoticed. Should air embolism occur it will cause a rapid or sudden fall in blood pressure, and if this is severe the patient's head should be lowered immediately. In the writer's opinion, the advantages provided by the sitting position in the approach to tumours in the posterior fossa far outweigh the danger of air embolism.

Meningiomas

In the treatment of meningiomas it has long been the aim to remove them as completely as possible. It is disquieting therefore to find in a careful follow-up of a large series of these intracranial tumours (Simpson, 1957) that the rate of recurrence was 9 per cent in those in which the tumour was thought at operation to have been removed completely with its dural attachment and any abnormal bone, and 19 per cent in cases in which all visible tumour was removed and its dural attachment was coagulated with diathermy. It is notable that in these two groups, of 19 recurrent growths examined only 6 could be considered to show evidence of malignancy.

Epidermoid and dermoid tumours and Rathké-pouch tumours

A rather conservative policy has been advocated in the treatment of two types of tumour of developmental origin. Reviewing a large series of intracranial epidermoid tumours, Tytus and Pennybacker (1956) wisely stressed how slowly these grow, and pointed out that where the capsule is adherent to vital structures it is best left behind and only the tumour contents removed. Likewise Northfield (1957),

reporting a series of 49 Rathké-pouch tumours, has clearly demonstrated the dangers of attempting complete removal when these extend above the sella turcica. When the growth involves the third ventricle and obstructive hydrocephalus is present, ventriculocisternostomy followed, in some cases, by transventricular exploration and removal of as much cyst wall as possible is recommended.

Fifth nerve neurofibromas and acoustic neuromas

Conversely, it is evident that intracranial neurofibromas arising from the fifth nerve are still best treated by total removal when this is possible. Olive and Svien (1957) describing 13 cases of fifth nerve neurofibroma pointed out the difficulties in diagnosis of these rare tumours and confirmed the finding that some cases show no evidence of dysfunction of the trigeminal nerve (Jefferson, 1955). Five cases required re-operation after periods ranging from 2 months to 6 years, and 1 died from recurrence after 2½ years In the treatment of acoustic neuromas, most neurosurgeons feel that total excision when possible is the operation of choice and the results of intracapsular removal, owing to the likelihood of recurrence and persistent neurological disability, are on the whole unsatisfactory.

Gliomas

Little change has taken place in the treatment of intracranial gliomas, but Fowler and Matson (1957) advocating an intracranial approach to gliomas of the optic nerves have produced encouraging results. Elvidge and Martinez-Coll (1956) in a long-term follow-up of a series of astrocytomas treated by operation, and in some cases deep radiotherapy, have produced post-operative survival rates as follows·

Astrocytoma diffusum (19 cases)—8 (42·1 per cent) survived more than 8 years.

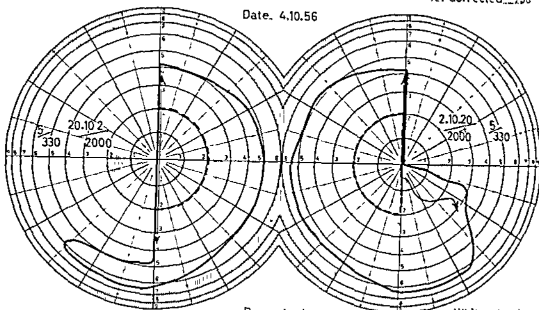
Gemistocytic astrocytoma (18 cases)—8 (44·4 per cent) survived from 4 to 10 years.

Pilocytic astrocytoma (39 cases)—average survival period 8 5 years

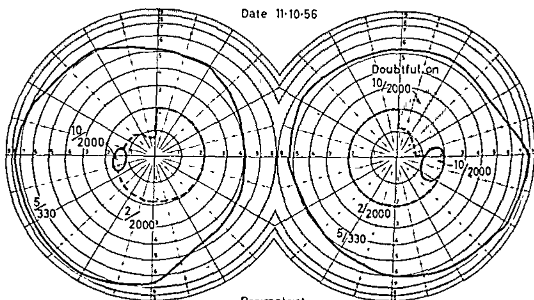
In dealing with this type of malignant tumour Lindgren, Lofgren and Lundberg (1957) have suggested that, after removal of the tumour, tantalum powder should be dusted into the tumour cavity Subsequent radiographs would then provide radiotherapists with the exact operation site in the brain, and films taken at intervals would show, by alteration of shadows, when regrowth was occurring

Pituitary adenomas

In the United States of America there has been a tendency to treat pituitary adenomas in the first instance by irradiation rather than surgery, even though the growth may be causing visual failure This view is reflected by Horrax (1958) who showed that in a period 1932–49, of 89 patients suffering from pituitary adenoma with visual impairment treated by primary irradiation, 62 9 per cent later required operation because "vision was not held at a useful level". However, with improved radiotherapeutic techniques, this figure in 66 patients was reduced to 12 1 per cent between the years 1950–55 Nevertheless, in Great Britain it is still generally believed that the best method of treatment of such cases is by operation, followed by irradiation. Operative removal of a pituitary adenoma in many cases produces a dramatic improvement in vision even though this may have



(*a*)



(*b*)

[illegible] fields immediately [illegible] 5/24, V.A.R. 6/36. [illegible] our. Visual fields [illegible] -*Hall*)

been severely affected (Fig. 87*a* and *b*), and it is not considered that irradiation only would be as effective in restoring vision It is also thought that deep radiotherapy in preventing recurrence of growth is likely to be more effective when the main mass of the growth has been removed; and in a few cases it may be impossible to be certain without operation that one is not dealing with a radioresistant tumour, such as a craniopharyngioma or suprasellar meningioma. Moreover, operative risks have recently been reduced by the administration of cortisone or ACTH (Tytus, Seltzer and Kahn, 1955; Jefferson, 1957), but it is clear from Horrax's findings that primary irradiation may be of great value in the treatment of cases where the risk of operation is poor.

INFANTILE HYDROCEPHALUS

Pathology

The pathology of hydrocephalus has been carefully demonstrated and analysed by Russell (1949) In the vast majority of cases the condition is due to an obstruction in the cerebrospinal fluid pathways, but excessive formation of cerebrospinal fluid due to hypertrophy of the choroid plexuses has been described (Davis, 1924) and defective absorption may rarely occur owing to thrombosis of the intracranial venous sinuses Obstruction may be produced by congenital malformations, chronic inflammation and by tumours. Common congenital malformations are atresia or forking of the aqueduct of Sylvius and the Arnold-Chiari malformation, often associated with a spinal meningocele. Chronic inflammation may cause gliosis of the aqueduct, or plastic arachnoiditis about the outlet from the fourth ventricle and in the basal cisterns. The latter may be brought about by meningitis or subarachnoid haemorrhage due to birth trauma and other causes (Foltz and Ward, 1956) Tumours which may cause obstruction are medulloblastoma and ependymoma in the fourth ventricle, gliomas of the pons and optic nerves or chiasm, craniopharyngioma and benign congenital cysts at the third ventricle.

Investigations

The first clinical sign of hydrocephalus is undue enlargement of the head with delay in closure of the fontanelles The average normal circumference of the head is 13 inches at birth, 17 inches at 6 months, 18 inches at 12 months, and 19 inches at 2 years (Westropp and Barber, 1956) In the investigation of hydrocephalus phenolsulphonphthalein (phenol red) was first used by Dandy and Blackfan (1913); the dye was injected into a lateral ventricle and lumbar puncture was then performed to determine whether it would pass freely from the ventricles into the cerebrospinal fluid in the lumbar sac. If this did not occur the hydrocephalus was "non-communicating", that is, there was an obstruction between the lateral ventricle and the lumbar sac. If dye was found in the lumbar fluid the hydrocephalus was "communicating" in type, but this did not exclude a basal cistern block. They also investigated the rate of excretion of the dye in the urine, and this has been further studied by Laurence (1957). Normally, not less than 40 per cent of the dye injected into the lumbar sac and 25 per cent injected into a lateral ventricle will be excreted within 6 hours of instillation. Thus, if the dye is injected into the lumbar theca a delay in excretion will indicate a block at the basal cisterns.

If this is normal but there is a delay in excretion after injection into the ventricles, there must be a block between the lateral ventricle and cisterna magna. Approximately one-third of all cases of hydrocephalus undergo spontaneous arrest and repeated *dye excretion* tests often give an indication when this is likely to occur.

Lumbar air encephalography using up to 50 millilitres of air under general anaesthesia is a valuable *investigation in* demonstrating the site of the block. This may show (Fig. 88) air freely entering the enlarged ventricles but failing to



FIG. 88 —Infantile hydrocephalus. Lumbar air encephalogram showing air in grossly dilated ventricles with air trapped in the basal cisterns. There is no air over the cerebral cortex

pass out from the basal cisterns into the subarachnoid space over the surface of the cerebral hemispheres On the other hand, it may demonstrate normal filling of the subarachnoid spaces over the surface of the hemispheres but failure to enter, the whole or part of the ventricular system. More rarely evidence of a valvular block may be demonstrated, in that air will pass into all parts of the cerebrospinal fluid pathways but the lateral ventricles may be enlarged without corresponding enlargement of the third or fourth ventricles. In such cases Myodil ventriculography may be indicated

Treatment

In treating infantile hydrocephalus operation should, of course, be avoided when tests and repeated measurement of the circumference of the head indicate a reasonable chance that spontaneous arrest may occur in the near future. In non-

communicating hydrocephalus it may be possible to relieve the obstruction by dividing arachnoid adhesions at the outlet of the fourth ventricle or by removing a tumour. When this is not possible a form of short-circuiting operation may be performed, such as anterior third ventriculostomy (Scarff, 1951) or ventriculocisternostomy (Torkildsen, 1948). Communicating hydrocephalus has been treated by drainage of cerebrospinal fluid from the lumbar sac into the peritoneal cavity and ureter. In addition, both types of hydrocephalus have been treated by drainage of fluid from a ventricle through a tube into the subdural space, peritoneal cavity and ureter. The most satisfactory of all these procedures is probably theco-peritoneal drainage when this is possible, but even this sometimes fails owing to the formation of peritoneal adhesions about the end of the tube. Theco-ureteric and ventriculo-ureteric anastomoses have the drawback that there is severe salt depletion and always the risk of meningitis through urinary infection. Excision and destruction by diathermy of the choroid plexuses in the lateral ventricles have been tried in order to reduce the formation of cerebrospinal fluid (Dandy, 1918), but this has not been used commonly in Great Britain. Ideally, the best method of treatment would be to short-circuit the flow of cerebrospinal fluid from the ventricles directly into the blood stream, and to do this a silicone tube and valve has recently been devised and used (Pudenz and his colleagues, 1957). One end of this is introduced into the right lateral ventricle and the tube is then led subcutaneously and inserted into the right jugular vein so that its distal end reaches the superior vena cava or right atrium of the heart. It may prove to be the best method of treatment in a high proportion of cases, but before such an operation is employed it is emphasized that patients should be investigated fully in order to determine the site of the block and whether a lesion such as a tumour could be better treated by excision.

THROMBOSIS OF THE INTERNAL CAROTID ARTERY

Since thrombosis of the internal carotid artery was first demonstrated angiographically by Moniz, Lima and de Lacerda in 1937, it has gradually become recognized as a not infrequent cause of severe neurological disability.

Symptoms and signs

In approximately 35 per cent of patients there is hemiplegia of rapid onset associated with aphasia if the dominant hemisphere is involved. There is also, sometimes, severe headache and loss of consciousness In approximately 25 per cent of patients gradually progressive hemiparesis may occur over a period of many months. At first there is usually weakness and paraesthesia of the upper limb followed by similar symptoms in the lower limb, sometimes with loss of intellect and disturbance of speech. The [illegible]
sudder [illegible]
of dys [illegible]
in the eye on the affected side, and there may also be loss of consciousness during the attacks. Complete recovery may occur after the attacks on many occasions, but ultimately in many cases, after a series of attacks, complete hemiplegia occurs (Johnson and Walker, 1951)



(a)



(b)

FIG. 89.—(a) Partial occlusion of internal carotid artery by thrombosis. Arterial phase of cerebral angiogram. Dye has been injected into the common carotid artery. There is good filling of the distal part of the internal carotid artery with some delay in filling of the cerebral vessels (b) The same case showing the termination of the common carotid artery with severe obstruction at the carotid bifurcation The origin of the internal carotid artery is almost occluded but a thin stream of dye just passes the thrombus The origin of the external carotid artery is severely narrowed but there is good filling of its branches beyond the thrombus.

The majority of patients affected have other evidence of vascular disease and in consequence it is a disease largely affecting the older age groups However, it may occur spontaneously in younger people without other evidence of vascular disease and it has been known for some time to follow direct and indirect injury to the carotid arteries in the neck.

Diagnosis

Angiography

Palpation of the carotid arteries in the neck is of little value in making a diagnosis, since it is impossible to differentiate between pulsation in the internal and external carotid arteries. Angiography is the essential investigation in making a diagnosis. This usually shows an obstruction in the internal carotid artery at or immediately beyond the bifurcation of the common carotid artery. Less commonly the obstruction may be in the internal carotid artery close to its termination and immediately beyond the origin of the ophthalmic artery.

When the obstruction is at the origin of the internal carotid artery, an angiogram may sometimes show filling of the distal part of the carotid siphon and anterior and middle cerebral arteries, the dye having reached those vessels through the external carotid artery, orbital vessels, and ophthalmic artery. Sometimes when the obstruction is incomplete the cerebral angiogram may be apparently normal or the flow only slightly delayed. It is therefore vital in such cases, when internal carotid thrombosis could be suspected, that further views are taken of the neck to show the region of the carotid bifurcation. By this means a partial occlusion of the vessel may be demonstrated (Fig. 89*a* and *b*)

Angiography demonstrating filling of only the external carotid artery cannot be taken as evidence of internal carotid artery thrombosis. Further views should be taken of the neck, if necessary after the needle has been re-introduced lower down, to show the carotid bifurcation

Treatment

Until recently no adequate treatment was available. Sympathectomy was sometimes performed with little improvement, and the thrombosed vessel was sometimes exposed and divided in the hope of reducing cerebrovascular spasm (Johnson and Walker, 1951). Recently Rob and Wheeler (1957) have shown that it is possible to reconstruct the vessel in some cases when the obstruction is at the proximal end of the vessel. Unfortunately this is rarely possible when the occlusion is complete, for when complete occlusion occurs thrombosis rapidly extends up the greater part of the internal carotid artery as far as the ophthalmic artery. The operation has not proved to be of much value when severe and prolonged hemiparesis has occurred beforehand. If, therefore, this form of surgery is to be effective, patients should be operated upon before the vessel has been completely occluded by the thrombus and before they have developed long-lasting and severe disability.

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SURGERY OF THE SPINAL CORD

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GENERAL CONSIDERATIONS

Compression of the cord and cauda equina

Compression of the cord and cauda equina has been investigated by Tarlov (1957) of New York who found that the Schiff-Sherrington phenomenon (transitory extensor rigidity of the fore-limbs following compression of the cord in the mid-thoracic region) is not present on compression of the cauda equina. The cauda equina is also more resistant to and tolerant of compression than the cord. Tarlov regarded compression paraplegia as due to mechanical deformation rather than anoxia because of its instantaneous onset, the histological changes which take place and the form of the action potentials. He found that the longer the time required for compression paraplegia to develop and the shorter the duration of complete paralysis, the sooner did recovery take place after relief of the compression.

Syndrome of occlusion of the anterior spinal artery

This syndrome is becoming well recognized since Steegman in 1952 reported 6 cases. The anterior spinal artery, which extends the whole length of the cord in the median anterior sulcus, arises by branches from the two vertebral arteries at the level of the foramen magnum. It is joined by anterior radicular arteries which vary in size and number. Its branches supply the anterior and central masses of grey matter and the anterolateral funiculi, consequently, occlusion results in muscular weakness with loss of pain and temperature sense and impaired sphincters. Tactile, discriminatory and joint senses are unaffected because the posterior columns are spared.

Peterman, Yoss and Corbin (1958) from the Mayo Clinic have recorded 10 cases of anterior spinal artery occlusion. The patients varied in age from 13 to 70 years and the level of the cord affected varied from C.7 to Th.12 and, while in all cases pin-prick and temperature sensations were diminished, in only 2 was there slight impairment of the function of the posterior columns. The cause of the syndrome was not apparent in 4 cases, in 2 it followed occlusion of the aorta during surgical procedures, and in 4 others the lesion was consequent upon syphilis, a haemangioma, fracture of a cervical vertebra and coarctation of the aorta respectively.

Another case, probably the first to be described at so early an age, has been

reported by Lindquist (1957) in a healthy boy aged 6 years. Symptoms appeared suddenly with tetraplegia, dissociated anaesthesia and sphincter involvement. Steady improvement occurred but recovery was incomplete.

INJURY

The treatment of a patient with an injury to his spine should begin at the scene of the accident because mismanagement in handling or transportation may produce or intensify an injury of the cord When a spinal lesion is suspected the alignment of the spine must not be changed except it be done with an understanding of the mechanism of production of the injury. Some clue as to the way in which the injury has occurred may be gained from the initial inspection of the patient: for example, a facial injury would suggest that there had been hyperextension of the cervical spine, or a kyphos at the site of the lesion that it had been caused by flexion of the column. Delayed paraplegia has occurred in some cases in which the nature of the injury has not been recognized at the time and the patient has even climbed out of an aircraft or walked from the scene of the accident to become paraplegic later (Rogers, 1945).

Surgical treatment

In general, spontaneous improvement contra-indicates operative treatment while an increase in the neurological deficit calls for it. Operation should be undertaken if there is an open wound, if there is an obvious encroachment on the spinal canal or investigation shows that spinal block is present. Laminectomy for contusion without spinal block is still debatable (Rogers, 1953). There is experimental evidence in animals that immediate decompression of the cord by incising the pia mater enhances recovery of its functions and immediate operation has been undertaken in some clinics in all cases of fracture dislocation with cord lesions, but for the most part with disappointing results. Probably the majority of cases of acute spinal injury, like the majority of cases of acute head injury, are best treated conservatively. Incisions made into the contused cord, except by the hands of the highly skilled, may do more to damage the structure of the cord than to improve its function by decompression of a subpial effusion.

Fracture of the odontoid process

Fracture of the odontoid process is sometimes seen after road accidents and probably considerable violence is necessary to bring it about. Blockley and Purser (1956) have analysed 51 cases Severe pain is a feature in those who survive the injury and about 10 per cent are tetraplegic Below the age of 6 years the odontoid is separated from the body of the axis by a cartilage plate and separation in a young child is usually followed by bony union. In adults, however, union is fibrous and occasionally there is a late appearance of cord symptoms. Early treatment should be by light traction by a skull caliper. Backward movement of the odontoid in cases where the transverse ligament has been weakened at or separated from its bony attachment by disease such as tuberculosis may cause medullary compression and require laminectomy of the atlas for its relief.

HAEMORRHAGE

Extradural spinal haemorrhages are rare by comparison with similar intracranial lesions and few cases have been reported. In 1956 Alderman in the United States of America in reporting 1 case was able to find only 14 recorded cases, 3 of which, including his own, were due to dicoumarol therapy. Since then Ainslie (1958) has reported 4 cases of paraplegia due to spontaneous haemorrhage which occurred in elderly hypertensive subjects, 3 of whom were women aged 73, 63 and 67 years respectively, and the fourth a man aged 70 years. The haemorrhage was extradural in 3 cases and subdural but extra-arachnoid in 1, the woman aged 67 years This patient recovered following laminectomy and evacuation of the haematoma; in the extradural cases of which 2 were operated upon the paraplegia was permanent. Pain at the site of the haemorrhage was a constant clinical feature, followed by the symptoms of compression of the cord which developed either immediately or more slowly over a period of hours or days. Haemorrhage from an angioma may produce a similar picture and Ainslie recorded a case in a man aged 32 years who, while walking along the street, was seized with severe pain in the back of the neck and left side of the chest and lost control of the lower limbs and left arm. Lumbar puncture yielded cerebrospinal fluid stained with blood, the source of which was an angiomatous malformation affecting the lower cervical cord.

TUMOURS

Diagnosis

The possibility of a spinal tumour should never be forgotten as it is important to recognize the early signs produced by it so that diagnosis may be established and treatment instituted before the cord is irreparably damaged. Bloom, Ellis and Jennett (1955) have published a list (Table) of incorrect diagnoses which had been made in 28 patients who had spinal tumours.

TABLE

SOME INCORRECT DIAGNOSES IN 28 PATIENTS

Diagnosis	*Cases*
Fibrositis, rheumatism	10
Prolapsed disc, sciatica, neuritis	10
Functional, hysteria, neurosis	9
Disseminated sclerosis	5
Tuberculous spine	4
Poliomyelitis	3
Peripheral neuritis	2
Syringomyelia	2
Subacute combined degeneration	1
Neurosyphilis	1
Cervical rib	1
Renal colic	1
Peptic ulcer	1

The present author has removed spinal tumours from patients in whom root pain had led to a mistaken diagnosis and the gall-bladder or appendix had been

removed or the kidney explored before the true nature of the case had been recognized.

Benign tumours

Spinal tumours are either benign or malignant, primary or secondary. The commonest benign intrathecal tumour is the neurinoma followed closely by the meningioma which occurs slightly more often in women than in men. Dumb-bell tumours are either neurinomas or fibromas and the intraspinal portion may be either intradural or extradural. Rarer benign tumours are lipomas which may be intradural or extradural or both, and haemangiomas The case has been reported of an extradural haemangioma in a man aged 66 years, in whom a transitory paraplegia occurred 7 years before a persisting recurrence of the disability caused him to seek relief which followed removal of the tumour (Rogers, 1955) Newman (1958) has drawn attention to paraplegia in cases of angioma arising during pregnancy and has reported 3 cases occurring in women aged 24, 34 and 35 years respectively. Two of the tumours were extradural while the third was intradural but associated with an angioma of the third lumbar body. Balado and Morea (1928) reported a remarkable example of a haemangioma occurring in a woman aged 36 years, who over the course of 10 years had 8 pregnancies and developed spastic paraparesis during 7 of these. The tumour was in the upper thoracic region and was extradural. It is suggested that the cord compression which thus comes about in pregnancy may be the result of venous congestion in the lesion or alternatively the effect of hormones on the walls of the vessels of which it is composed. Cavernous haemangiomas on the skin have been observed to enlarge in early pregnancy and to retrogress at its termination. The occurrence of a transverse spinal cord lesion during pregnancy should raise the possibility of an angioma as the cause

Malignant tumours

The commonest primary, malignant extradural tumour is the plasmacytoma. Secondary malignant tumours are commoner than primary ones and have a predilection for the spinal epidural space, probably because of the large venous lakes which it contains In a series of malignant tumours reported from the Surgical Unit at Cardiff the sources of the metastatic or secondary malignant tumours were bronchus, breast, prostate gland, testis, thyroid gland, caecum and adrenal gland respectively The remarkable effect of the dura mater in protecting the cord from invasion by malignant tumours in the epidural space and the ease with which such tumours, in contradistinction to inflammatory lesions, may be stripped from it has been commented upon (Rogers, 1958). The author has seen the vertebral body invaded and pedicles destroyed by secondary carcinoma, yet the dura remains quite intact and free from tumour and he has opened the dura and divided nerve roots to relieve pain and found the cord and roots, like the dura itself, free from tumour.

In cases of malignant as well as of benign tumour laminectomy and relief of cord compression should be carried out whenever the patient's condition permits. A combination of surgery and radiotherapy may relieve suffering and prolong life;

furthermore, it is not always possible to determine the type of tumour before operation.

Arteriovenous aneurysms

Hook and Lidvall (1958) recently reported 2 cases of spinal arterio-venous aneurysm, one of which occurred in a man aged 31 years who had severe subarachnoid haemorrhages and a blowing murmur which could be heard on auscultation of the cervical spine. At the level of the second cervical vertebra there was an aneurysm the size of a walnut. The second case occurred in a woman aged 34 years who also had subarachnoid haemorrhages from an aneurysm in the cervical region. These lesions are usually best treated by decompression alone but occasionally it may be possible, as in the case of the corresponding intracranial lesions, to extirpate them One case in which this was successfully carried out was reported by Scoville (1948); the arteriovenous aneurysm involved the conus region of a boy aged 14 years.

Dermoid and epidermoid tumours

In 1956 Choremis and his colleagues in the paediatric clinic at Athens reported 6 cases of intrathecal epidermoid tumours in children aged between 7 and 12 years all of whom had from 3 to 7 years previously been treated successfully for tuberculous meningitis, and in the course of this treatment had been subjected to many spinal punctures. They suggested that epithelial cells implanted by lumbar puncture might be the source of some of these tumours. Lumbar puncture cannot be the explanation of all of them, however, as the present author reported (Rogers, 1956) a case in a boy aged 6 years in whom one of these tumours was removed from the upper thoracic region with recovery from his spastic paraparesis and in whom no previous lumbar puncture had been performed. An extensive tumour lying between the tenth thoracic and first sacral vertebrae successfully removed from a man aged 35 years by Bose in Calcutta (1957) appears to have been an epidermoid In a paper on pearly tumours in relation to the central nervous system Tytus and Pennybacker (1956) recorded 7 cases in which these tumours lay inside the spinal canal. Six of them were in part intramedullary; associated dermal sinuses were present in 2 Five of the tumours were classified as dermoids, 2 as epidermoids The ages of the patients varied between 6 months and 40 years. Complete removal of the tumours was effected in only 3 cases, but in only 1 have there been signs of a recurrence over a period of 8 years and the tumours are apparently very slowly growing.

After operation on these cases, especially if it has not been possible to remove the tumour completely, a pleocytosis is liable to occur in the cerebrospinal fluid and an aseptic meningitis may be present for weeks before finally clearing

Vertebral osteoclastomas causing compression of the cord

These are rare tumours of the vertebrae Whalley (1958) recorded 4 cases, 3 of which were treated by decompression of the cord and subsequent irradiation, the fourth by irradiation alone. All 4 made good recoveries. Two of the patients were girls aged 12 and 15 years respectively, the third a woman aged 29 years and

the site of the extrusion from spondylosis in which bony proliferation accompanies degenerative changes in discs which result in the production of transverse bars in front of the dura. These changes are essentially degenerative and usually occur at a later period of life than does the localized extrusion which produces either root or cord compression. Brain, Northfield and Wilkinson (1952) considered the primary lesion in cervical spondylosis to be a degeneration of the intervertebral discs, to which changes in the bodies of the vertebrae and the neurocentral joints are secondary. The neurological manifestations are well described in their paper and in that by Spillane and Lloyd (1952).

In 1952 Russell, Bedford and Bosanquet reported a case of degeneration of the spinal cord associated with cervical spondylosis which occurred in a married woman aged 71 years with tetraparesis and a protein content of 90 milligrams per cent in the lumbar cerebrospinal fluid. At necropsy degenerative changes were found in the cord at the level of the fifth, sixth and seventh cervical segments and the writers considered that it is probable that abnormal fixation of the cord may have rendered it vulnerable to normal neck movements. They commented on the thickened denticulate ligaments and fibrous nerve roots. An excellent account of the normal and morbid anatomy of the cervical spine has recently been published by Payne and Spillane (1957) in which, incidentally, they regard the neurocentral joints of Luschka as fissures in the intervertebral discs rather than articulations as they were considered to be by the German anatomist. They distinguished cervical spondylosis, which they regard as a degenerative process affecting the vertebral bodies and the intervertebral discs, from osteoarthritis of the synovial apophyseal joints which may occur independently of spondylosis. They found variations in the size of the normal cervical spinal canal which may be reduced by spondylosis and believe that myelopathy is more likely to occur when the original dimensions of the canal are smaller than average. They also suggested that interference with the anterior spinal and radicular arteries is a likely factor in producing myelopathy.

A sufficiently large series of cases from which to deduce the value of surgical treatment of cervical spondylosis is not yet available but even more important is the question of what this treatment should be. The present author believes that it has often been too limited and incorrectly directed to producing local decompression rather than to increasing the mobility of the cord and thereby relieving pressure on its chief blood supply, the anterior spinal artery. This can be done only by an extensive cervical laminectomy, division of the dentate ligaments on either side throughout the extent of the exposed cord and by leaving the dura closed in by gel foam so as to enlarge the theca He has now performed this operation in a series of cases in which early results have been pleasing.

SCIATICA

It is now well recognized that the commonest cause of persistent sciatica is a radiculitis due to an intervertebral disc lesion. In about 10 per cent of such cases a cauda equina tumour is responsible and lumbar puncture, therefore, in these persistent cases should always be performed, the colour, protein and cellular content of the fluid being noted and the Queckenstedt phenomenon examined. The wave of enthusiasm for early operation in so many cases of sciatica has receded and given place to a more balanced judgment. Only after lumbar puncture has

excluded the likelihood of a tumour and conservative measures such as medical (bed) rest or orthopaedic (plaster) rest have been given fair trial should operation be advised. Myelography is sometimes very helpful. When operation is undertaken a good result may be expected if the disc herniation is localized and prominent and if *after incising its coverings* a large mass of nuclear material extrudes and can be readily withdrawn from the disc space. There is no need to employ any form of spinal fusion or fixation subsequently. Where disc extrusions produce clinical pictures resembling tumours they are of course treated as such by exploratory laminectomy (Rogers and Langmaid, 1957). In operating on disc cases, adequate exposure as in all operative surgery is the key to success. Schlesinger (1957) has emphasized this in the case of the lumbosacral disc. Jennett (1956), in a paper on compression of the cauda equina by prolapsed intervertebral discs, also advocated adequate exposure. There can be no doubt that difficulties have occurred through ill-advised attempts to operate through "key-hole" approaches. Of the cases studied by Jennett the common site of extrusion of the disc was either L.3 or L.4, and there was a striking preponderance of men at or beyond middle age.

Hypertrophy of the ligamentum flavum (subflavum)

Pollard (1956) from the Mayo Clinic reported a case of ligamentous thickening in a woman aged 51 years who for 3 years had suffered from recurrent back and leg pain Myelography showed a posterior dural defect, regarded as due to a hypertrophied ligament which was found at operation. The fourth and fifth lumbar discs were apparently normal. Hypertrophied ligamenta subflava constitute probably less than 3 per cent of the lesions causing back pain and sciatica but an association of thickened ligaments with disc lesions has been noted. Docherty and Love (1940) studied 50 ligaments obtained at operations for disc herniations and were able to demonstrate thickening and fibrosis in these as compared with ligaments obtained at necropsy. It is uncommon, however, for the ligament to be so thickened as to cause a defect in the myelogram as in Pollard's case.

CALCIFIED HERNIATED DISC IN A CHILD

Peck (1957) reported the case of a boy aged 12 years who, a week after a fall, had pain in the mid-scapular region and difficulty in walking. Radiographs showed a calcified disc extrusion in the mid-thoracic region. There was no evidence of spinal block on lumbar puncture and the protein content of the fluid was only 27 milligrams per cent, but myelography revealed an anterior compression at the level of the calcified disc Recovery followed the extradural removal of the nuclear material.

RARER CORD LESIONS

Spinal lithiasis

Calcification and ossification in the arachnoid mater is not uncommon and the author has seen it in young as well as in elderly patients, but Faeth (1958) has reported a curious case of calcification in the roots of the cauda equina of a woman aged 60 years, whose complaints were of vague lower abdominal pain and

retention of urine. Myelography revealed a filling defect between L 2 and L4 There were several calcareous stones which were adherent to the roots of the cauda. After removal of the stones the atonic urinary bladder which was the chief clinical feature recovered.

Arnold-Chiari malformation and the spinal cord

Arnold in 1894 and Chiari in the following year described this malformation of the hind-brain characterized by the displacement of part of the cerebellum through the foramen magnum into the spinal canal where it may compress the upper part of the cord. Its association with hydrocephalus, hydromyelia of the cervical cord and with meningomyeloceles is well recognized and in 1935 Russell and Donald reported necropsy studies of 10 cases of meningomyelocele in every one of which there was an associated Arnold-Chiari lesion. The lesion may be present in adults as well as in children and may merely be one of several congenital anomalies such as platybasia (Spillane, Pallis and Jones, 1957). A case occurring in a man aged 58 years with congenital basilar impression and presenting features of a progressive bulbar palsy has been reported from the Mayo Clinic by Lougheed and Baker (1957). Obstructive lesions in the region of the foramen magnum should be excluded before readily accepting a diagnosis of a systemic disease of the cord such as amyotrophic lateral sclerosis or disseminated sclerosis. This recalls a similar warning in the early days of myelography when spinal tumours were not infrequently overlooked under a mistaken diagnosis of disseminated sclerosis. The author can recall removing tumours from several patients in whom such a diagnosis had been made.

FLEXION SPASMS AND CONTRACTURES IN DISEASE OF THE SPINAL CORD

Platt, Russell and Willison (1958) have studied this problem. If a patient with spastic paraparesis is able to stand and walk even a few steps he is unlikely to be troubled by flexion spasms, the extensor group of muscles are able to maintain a balance with the flexors, but if for any reason he has to take to bed there is a tendency for flexor tone to predominate and spasms to occur and contractures may follow. Those who have to remain in bed should lie prone for several separate periods each day as this posture produces a powerful counter to flexion. In attempting to correct contracture deformities, the condition of the skin requires paramount consideration. Prolonged gentle pressure or traction will usually not be tolerated by it but greater forces over short periods may well be tolerated, for example, for 30 minutes 2 or 3 times daily. Operations such as obturator neurectomy, division of the tendon of the iliopsoas, transplantation of the hamstrings, section of the tendo achillis or division of the nerves to the gastrocnemius may also be helpful and give much relief to patients who already have flexion contractures.

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CERVICAL RIB AND THE SCALENUS SYNDROME

By LAMBERT ROGERS, C.B.E., V.R.D., M.Sc., M.D., F.R.C.S., F.R.A.C.S., F.A.C.S.

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Under this heading in *British Surgical Practice* (Volume 3, page 28) an account is given of the signs and symptoms which may be produced by irritation or compression of the brachial plexus by a cervical rib, or rarely by the first thoracic rib, and related structures such as fibrous bands and accessory scalene muscles Reference is also made to costoclavicular compression in which the clavicle plays a part. *Since the structures responsible for the patient's symptoms are thus various,* albeit all lie at the root of the neck, many writers have come to refer to the clinical features as the thoracic outlet (or inlet) syndrome, or the syndrome of the costoclavicular space.

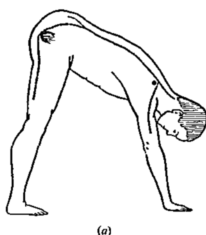
ANATOMY

The thoracic outlet [inlet (Cunningham)]: the costoclavicular space

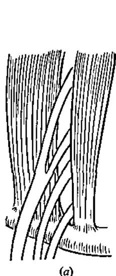
The superior aperture of the thorax is a narrow opening bounded by the first thoracic vertebra, the first pair of costal arches and the manubrium sterni and from it issue the great vessels and nerves to the upper limb. The opening may be asymmetrical if a cervical rib is present as this may vary in size from being little more than an enlarged costal element a few millimetres in length, to a massive and complete costal arch. In some cases the rib may be bony at its proximal end only and represented in the remaining part of its length by a fibrous band.

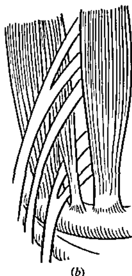
Contrary to what occurs in the lower limb and consequent upon *man's upright* posture, the neurovascular bundle as it leaves the upper thoracic opening to enter the dependent limb is sharply angulated (Fig 90). If, because of this angulation, movements of the arm result in friction or stretching of the lowest trunk of the brachial plexus by a rib or band, against which it is kept in close opposition by the contraction of the scalenus anticus muscle (Fig. 91 *a*, *b* and *c*), symptoms *may be* produced which constitute the scalenus or cervical rib syndrome. *The band may be part* of scalenus medius or some fibres of scalenus minimus (intermedius or pleuralis). These pass from the cervical spine downwards and outwards to reinforce Sibson's fascia by their expansion, and are in this respect peculiar to man and the apes and possibly, therefore, associated with the erect posture *(Leblanc, 1937)*

If as the subclavian artery leaves the upper thoracic opening movements of the arm result in its compression between the rib over which it passes behind, and the









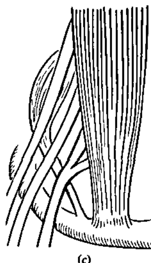


FIG 91 —(*a*) The lowest trunk of the brachial plexus angulated over sharp medial fibres of scalenus medius (*b*) An extra scalene slip causing compression against the medial fibres of the scalenus medius (*c*) The lowest trunk lying over a band extending downwards to the first rib from an enlarged cervical costal element.

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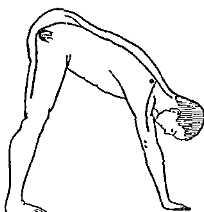
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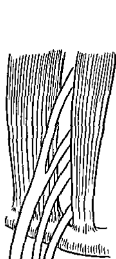
If as the subclavian artery leaves the upper thoracic opening movements of the arm result in its compression between the rib over which it passes behind, and the



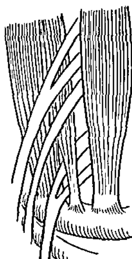
(*a*)



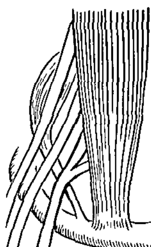
(*b*)



(*a*)



(*b*)



(*c*)

FIG 91 —(*a*) The lowest trunk of the brachial plexus angulated over sharp medial fibres of scalenus medius (*b*) An extra scalene slip causing compression against the medial fibres of the scalenus medius. (*c*) The lowest trunk lying over a band extending downwards to the first rib from an enlarged cervical costal element

clavicle in front, a clinical picture of intermittent ischaemia is produced (costoclavicular compression).

The subclavian artery is often prominent in the supraclavicular triangle and as long ago as 1861 H. Coote of St. Bartholomew's Hospital gave a good description of a cervical rib which so pushed the artery upwards and forwards that it resembled an aneurysm. He removed the rib with relief of the patient's symptoms.

The artery may not only be prominent but also dilated beyond the site of its constriction as was noted by Halsted (1916) and has often been commented upon by others. The cause of this distal dilatation is at first sight puzzling but is explicable by the effect of eddy currents and Bernouill's theorem of hydrodynamics, that the gain in kinetic energy at a constriction in a pipeline is at the expense of pressure energy, the pressure falling at the constriction and rising immediately beyond it.

COSTOCLAVICULAR COMPRESSION

The cases which come into this category form but a small proportion of the total comprising the upper thoracic syndrome.

The type of cervical rib most likely to play a part in costoclavicular compression is the long well-developed and laterally placed one [illegible] *short, stumpy rib with a pointed end to which a* [illegible] 1953) The costoclavicular space is encroached up[illegible] an asymmetrical upper thoracic opening and if exploration is carried out under local analgesia the narrowing of the costoclavicular interval and the squeezing of the artery with movements of the shoulder girdle may be verified. It is important to recognize the mechanical compression in these cases because scalenotomy alone will not relieve the patients and the artery will be effectively freed only by removal of one of the bony struts between which it is compressed. In fact scalenotomy alone may make the patient with costoclavicular compression worse, as in a case recorded by Le Vay (1945). The movement which causes the compression is usually backward and downward retraction of the shoulder but the relationship of the abnormal rib [illegible] and slightly backward movement of the shoulder produced compression [illegible] artery which was freed after removal of the anterior part of the rib (Rogers and Aldis, 1947).

Complications of costoclavicular compression

If there is intermittent compression of the artery between the bony struts of rib and clavicle, the vessel in the course of time is likely to be injured at the site and a local lesion produced such as periarteritis, an aneurysm, or thrombosis of the artery. In one such case a man aged 45 years employed as a garage-hand had a subclavian aneurysm which the author excised. Thirteen years later the author removed the distal part of the rib as it was beginning to cause neural symptoms. Five years later the patient is well and still working in a garage.

If the lesion is untreated detached pieces of blood clot from the site of such injury may result in embolic obstruction of peripheral vessels and cases of gangrene

have been reported. Clare, Schilp and Starr (1956) have recorded a case in a seaman aged 39 years with bilateral cervical ribs. The artery was compressed between the clavicle and the cervical rib on the left side and was dilated distal to the constriction. Excision of the rib and cervical sympathectomy were ineffective and a gangrenous forearm had to be amputated. Samiy (1955) reported a case in a woman aged 23 years of occlusion of the internal carotid artery associated with a right cervical rib and a thrombosed subclavian artery on the same side. The author has recently operated upon a woman aged 28 years who had a complete cervical rib on the right side. One week before admission to hospital she had sudden intense pain in the hand and fingers which were cold and in which there were colour changes following the lodgement of an embolus at the bifurcation of the brachial artery. In her case there was no aneurysm. Improvement in collateral circulation followed freeing of the artery and necrosis was limited to the tip of the middle finger. Naylor (1958) who has recently reported two cases of subclavian aneurysm associated with cervical rib, one in a woman aged 56 years, the other in a man aged 39 years, successfully excised the aneurysm and the anterior part of the rib in each case. He noted an early post-operative improvement of the peripheral circulation which he ascribed to release of vasospasm and advocates the combined operation of excision of both aneurysm and rib.

DIFFERENTIAL DIAGNOSIS

Median nerve compression at the wrist: the carpal tunnel syndrome

Since the publication of the original article in *British Surgical Practice* another syndrome, that of median nerve compression in the tunnel at the wrist through which the nerve enters the palm, has come into prominence and requires consideration in the differential diagnosis of the cervical rib syndrome (*see* also



FIG 92 —Wasting of lateral part of thenar eminence in a long-standing case of the cervical rib (thoracic outlet) syndrome Woman aged 60 years

section on Carpal Tunnel Syndrome). Some patients who have been operated upon for what was undoubtedly a brachial plexus lesion and have had relief following operation have subsequently appeared with the carpal tunnel syndrome. It may be that there is some common anatomical or pathological basis whereby the nerve trunks of certain subjects are abnormally sensitive to friction or pressure.

Thenar wasting

In cervical rib cases this is due to atrophy which affects chiefly the opponens and abductor pollicis muscles; the flexor brevis pollicis, as Wilson (1912) noted, usually escapes. This gives a characteristic appearance to the base of the hand (Fig 92) In the carpal tunnel syndrome the whole eminence may be slightly flattened, but the flexor brevis may again escape since as Highet (1943) has observed it often has an ulnar innervation.

Differentiation

The condition may be distinguished from the cervical rib or scalenus syndrome by its affecting older subjects, by the different character of the pain or paraesthesia, by the type of thenar wasting, by the fact that there may be sensory changes in the median compression syndrome, and by noting the effect of elevation and abduction *of the arm which relieves the scalenus but not the carpal tunnel syndrome.* Fixation of the hand and arm in slight flexion at the wrist opens up the carpal tunnel and relieves the symptoms of the median syndrome but has no effect on the plexus lesion at the root of the neck.

Other syndromes in differential diagnosis

In the original article, cervical disc lesions, ulnar neuritis and writers' cramp were considered in the differential diagnosis. Experience has shown also that certain cases of progressive muscular atrophy, by affecting the small muscles of the hand, may have a superficial resemblance to the scalenus syndrome, particularly if accompanied by some pain and discomfort. The tests to which reference has been made will, however, usually serve to differentiate the conditions. At first sight the clinical features of subacromial bursitis may be misleading but abduction of the arm increases the pain of this condition while it relieves the symptoms of the scalene syndrome Ulnar [illegible] age or in later life. The neur[illegible] peripheral lesion and if an accurate examination is made it is unlikely [illegible] difficulty. It has recently been suggested (Osborne, 1958) that like the carpal tunnel syndrome the cause of these cases of *ulnar neuritis may be compression* of the nerve at the distal end of the postcondylar groove on the humerus where, as it enters the forearm, it passes beneath the fibrous arch which bridges over the two heads of the flexor carpi ulnaris.

OPERATIVE TREATMENT

There is little to add to the description given in the original article (Volume 3, page 32) As stated there, an abnormal posterior scapular branch frequently arises from the third part of the subclavian artery and passing downwards and backwards between the trunks of the plexus causes the lowest trunk to be closely applied

to the main artery. This scapular branch should be divided between ligatures. When approaching the subclavian artery it is well to preserve the transverse cervical vessels so that they may take part in the collateral circulation should it be necessary to ligate the main artery. Care is necessary in clearing the subclavian artery itself as scalene muscle fibres are sometimes inserted into its adventitia The author has been able to demonstrate this in several cases.

The surgeon should not be content with anterior scalenotomy; in all cases the structure lying beneath the lowest trunk of the brachial plexus should be inspected and divided if it appears that the nerve trunk is stretched across it The author has had to re-operate on patients incompletely relieved by a previous division of the anterior scalene muscle alone and this has been the experience of others also (Raaf, 1955) The structure underlying the plexus may be a fibrous band, the medial tendinous fibres of the scalenus medius, an abnormal scalene slip or a rib, usually cervical, but in some cases it is the first rib and to free the plexus adequately part of this may require excision. White, Poppel and Adams (1945) reported a series of cases in which a rudimentary first rib was responsible and commented on the inadequacy of scalenotomy alone in such cases.

Before closure of the wound is undertaken careful haemostasis is necessary as otherwise a haematoma is liable to form and its subsequent organization to result in adhesions and plexitis with a return of symptoms For this reason some surgeons (Stammers, 1950) employ a glove drain for the first 48 hours.

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THE CARPAL TUNNEL SYNDROME

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HISTORICAL INTRODUCTION

Compression of the median nerve in the carpal tunnel, occurring without precipitating cause, was first described by Brain, Wright and Wilkinson in 1947. Before this there had been 2 reports of cases where similar compression had occurred in association with a local lesion at the wrist; Woltman (1941) recorded a unilateral median nerve lesion associated with arthritis of the wrist in which the symptoms disappeared after section of the transverse carpal ligament. He also suggested that the median neuritis found in some patients suffering from acromegaly was due to encroachment by hyperplastic tissue on the limited space between the carpal bones and the transverse carpal ligament In 1945 Zachary reported on 2 patients; in one there was a bilateral median nerve lesion associated with old fractures of the scaphoid and osteoarthritis, the left median nerve was found to be compressed in the carpal tunnel but there was no improvement in symptoms 3 months after a decompression operation; in the second case the median nerve lesion developed [illegible] malunited Colles's fracture and symptoms were relieved [illegible] Brain, Wright and Wilkinson [illegible] nen who had bilateral median nerve lesions at the wrist; the symptoms had developed gradually over a period of up to 5 years. At operation in all 6 patients the median nerve was found to be compressed where it passed beneath the transverse carpal ligament and swollen for about an inch above this. In all the patients there was rapid relief of pain and tingling, and improvement in motor and sensory signs.

In 1951 McArdle suggested that median nerve compression in the carpal tunnel was a common cause of the syndrome of acroparaesthesiae. This name had been

applied by Schultze (1893) to the condition of painful nocturnal paraesthesiae in the hands and fingers which frequently occurs in middle-aged women. A number of unconvincing hypotheses had been put forward to explain the condition, and in 1945 Behrman had suggested that the important factor in its causation was a minor degree of compression of the brachial plexus. In the same year Walshe stated that the cause of the condition was traction and compression of the lower components of the brachial plexus, and at times of the subclavian artery, by the first rib when there was hypotonia of the shoulder muscles and drooping of the shoulder girdles. The fact that a number of patients suffering from acroparaesthesiae improved with shoulder girdle exercises appeared to be in favour of this hypothesis. McArdle's view that acroparaesthesiae were frequently caused by median nerve compression in the carpal tunnel was confirmed by Kremer and his colleagues (1953). They operated on 40 patients with the clinical syndrome of acroparaesthesiae and in 37 there was immediate and permanent relief of pain; in 2 patients there was no relief of symptoms and on re-exploration it was found that the distal fibres of the transverse carpal ligament had not been divided, but after these had been divided at the second operation the symptoms were relieved; in a third patient a cyst arising from the flexor tendon sheaths and compressing the median nerve was found. This view that acroparaesthesiae are very commonly caused by median nerve compression has been confirmed by Garland, Bradshaw and Clark (1957) in a series of 53 cases and by Heathfield (1957) whose 80 cases form the basis for the description of the clinical features of the carpal tunnel syndrome in this article.

CLINICAL FEATURES

Median nerve compression in the carpal tunnel is considerably commoner in women than in men, the incidence being about 5 women to 1 man affected. The condition may occur at any time in adult life but about 50 per cent of cases are in the 40–60 age group The disorder is frequently bilateral, in 27 of the 80 patients in the St Bartholomew's Hospital series (Heathfield, 1957), with the right hand the more severely affected in 20, of the remaining cases the right hand was involved in 41 and the left in 12 patients When the left hand was predominantly affected there was no definite association with left-handedness. In a few cases there is a local lesion at the wrist as the precipitating cause of the compression, examples being an old fracture of the scaphoid, an old Colles's fracture, a ganglion, and arthritis of the wrist Occasionally there is an apparent familial tendency and we have seen typical examples in 3 sisters and in another family in 2 sisters. The condition is not uncommon in pregnancy, there were 8 cases in the St. Bartholomew's Hospital series, and in 2 others symptoms started immediately after delivery.

Clinically the cases can be divided into 2 major groups although there is considerable overlap between them, in the first there is a progressive lesion of the median nerve at the wrist as in the cases originally described by Brain, Wright and Wilkinson (1947), and in the second [illegible]

[illegible]

middle and ring fingers, this is followed in the course of weeks or months by

numbness and sensory impairment in the affected thumb and fingers which makes manipulation of small objects difficult. Together with the sensory symptoms, wasting of the outer part of the thenar eminence develops and weakness of the outer thenar muscles adds to the difficulty of using the thumb. In a few patients it is the appearance of muscle wasting which makes them get medical advice. In this group of patients there is wasting of the outer part of the thenar eminence (Fig. 93) with severe weakness and at times complete paralysis of abductor pollicis brevis and opponens pollicis together with cutaneous sensory impairment over the palmer aspect of the thumb and index finger and frequently also of the middle finger and lateral side of the ring finger.

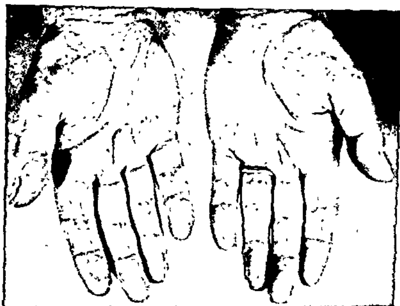


FIG. 93 —Wasting of the outer thenar muscles in a patient with a bilateral carpal tunnel syndrome

In the larger group of patients, attacks of painful paraesthesiae in the fingers are the presenting and often the only symptom. In the series of 80 patients paraesthesiae occurred only at night in 34 patients and only during the day in 22, while of the remainder the symptoms were worse at night in 17. The patient often wakes up in the early hours of the morning with a combination of painful tingling and numbness in the fingers; this may be relieved if the patient gets up and moves the arms about but she frequently wakes up again later with similar symptoms. The peripheral paraesthesiae are sometimes accompanied by diffuse pain in the front of the forearm and this may extend as high as the shoulder. The index and middle fingers and the thumb are usually most affected by the paraesthesiae but some patients say that all the fingers are affected, the little finger less than the others. On waking in the morning the fingers often feel stiff and swollen and there is difficulty in performing fine movements. Nocturnal paraesthesiae tend to be more severe after a heavy day's work, for example, after washing day, and diurnal paraesthesiae are frequently precipitated by knitting or sewing and by carrying a

heavy shopping basket. Paraesthesiae are notably intermittent in their occurrence and many patients find that they stop completely during a holiday and sometimes without any obvious cause.

In one-third of the patients with acroparaesthesiae there are no objective signs on examination but the others show wasting of the outer part of the thenar eminence, wasting which is sometimes more easily felt than seen, with some loss of power in abductor pollicis brevis. Slight cutaneous sensory impairment over the palmar aspect of the terminal phalanx of the index finger and thumb is frequently present and at times the sensory impairment is more extensive and extends to the base of the thumb and median fingers Tinel's sign is frequently absent over the carpal tunnel and is not a reliable sign in the diagnosis of median nerve compression In a few patients there is well-marked tenderness of the thenar muscles. Physical signs may be present a few weeks after the onset of symptoms or be entirely absent after the symptoms have been present for a decade. Brain, Wright and Wilkinson noted weakness of extension of the thumb in one of their cases which improved following division of the transverse carpal ligament, and another of their patients had loss of flexion of the terminal phalanx of the thumb. In 2 of our patients there was weakness of flexion of the terminal joint of the index finger, which was thought to be due to ischaemia of the tendon

SPECIAL TESTS

Tourniquet test

Gilliatt and Wilson (1953) described the effects of occlusion of the brachial artery by a sphygmomanometer cuff in patients with the carpal tunnel syndrome. In normal controls when the brachial artery is occluded, within 1 or 2 minutes there is a faint fluttering sensation in the fingers which gradually develops into tingling. This sensation is felt either diffusely throughout the hand and fingers or predominantly in the little and ring fingers. In 50 normal subjects tested by Gilliatt and Wilson the ischaemic tingling was never felt strongly in the median distribution without the ulnar fingers being equally or more severely affected In patients with carpal tunnel compression, within 30–60 seconds of arterial occlusion paraesthesiae usually developed in the thumb, index and middle fingers and sometimes also in the ring finger and consisted of intense tingling, often similar to the nocturnal paraesthesiae which had been the patient's major symptom. In some patients median sensory impairment appeared rapidly during ischaemia, easily detectable sensory changes often being found within 5–10 minutes of inflation of the cuff. We have confirmed these findings in a number of patients with carpal tunnel compression but the test is apt to give negative results in patients without definite physical signs and is only of limited diagnostic value

Electrical tests

Simpson (1956) tested the conduction time in the motor fibres of the median nerve by stimulating the nerve electrically with a brief condenser discharge, recording the contraction of the thenar muscles with a needle electrode. In 11 out of 15 patients in whom the carpal tunnel syndrome was thought to be present, there was delay in conduction distal to the wrist, as compared with the findings in

10 normal controls and in 15 other patients with different neurological and muscular disorders The decreased conduction speed was also demonstrated behind the elbow joint in a case of traumatic ulnar neuritis. In 3 out of 5 cases of median nerve compression the conduction time returned to normal after operation. Simpson also observed repetitive firing of motor units in 7 of his 15 cases; this had been previously observed in experimental ischaemia of the peripheral nerves by Kugelberg and Cobb (1951), and the former suggested that a similar "irritability" of the sensory fibres may explain the paraesthesiae and pain occurring in ischaemic conditions.

Gilliatt (1958) has elaborated Simpson's work and has devised a test for the rate of conduction in sensory fibres, using ring surface electrodes around the fingers and recording from different sites in the forearm and arm. His results show that there is a delay in sensory conduction beneath the transverse carpal ligament when the median nerve is compressed at that site.

These tests are interesting and can be valuable in the differential diagnosis of wasting and sensory loss in the hands; for example, in the differentiation of the wasting of the thenar muscles due to cervical rib pressure, from that due to the carpal tunnel syndrome, and the latter syndrome from radicular lesions causing sensory impairment in the fingers. They require special apparatus including a cathode ray oscilloscope and an operator trained in electrical stimulation, and are time consuming. Their future use will therefore probably be confined to large centres.

Splinting the wrist

Immobilization of the wrist joint in a plaster splint will often lead to remission of symptoms, and nocturnal paraesthesiae will rapidly respond to wearing the splint at bed-time. This test was helpful in 78 out of a recent series of 80 cases.

DIFFERENTIAL DIAGNOSIS

In the majority of patients the diagnosis of median nerve compression in the carpal tunnel is clear but there are several conditions which may cause diagnostic difficulty.

Spinal cord disease

If outer thenar wasting is a prominent feature motor neurone disease (progressive muscular atrophy) may be mistakenly diagnosed but in this condition there will nearly always be some muscle wasting in the other hand muscles, particularly the interossei; fasciculation is commonly present either in the wasted muscles or in muscles which have not begun to waste and an abnormality of the arm reflexes is usually present. Although paraesthesiae occasionally occur in motor neurone disease, objective sensory changes are not found The presence of muscle wasting and sensory changes in the hands may suggest a diagnosis of syringomyelia but, when these are strictly limited to the distribution of the median nerve and there is no impairment of the arm jerks, this disease can be excluded. Paraesthesiae in the fingers may be early symptoms of disseminated sclerosis and of subacute combined degeneration of the spinal cord, but full neurological examination will

usually give signs of spinal cord involvement in these disorders. We have seen the carpal tunnel syndrome develop in patients suffering from tabes dorsalis and from subacute combined degeneration, and the possibility of such an occurrence must be remembered.

Multiple peripheral neuritis

Paraesthesiae in the hands are common symptoms in multiple peripheral neuritis but similar symptoms will usually also be present in the feet and impaired tendon jerks are commonly found Peripheral sensory impairment is usually present but will not be confined to the median distribution. When paraesthesiae in the hands occur in a diabetic patient there is a tendency to ascribe them to diabetic neuropathy, in fact, this condition only rarely affects the upper limbs and we have seen several diabetic patients in whom the paraesthesiae were due to median nerve compression.

Cervical ribs and axillary inlet syndrome

In most patients in whom cervical ribs are causing neurological disturbance, wasting affects the intrinsic hand muscles supplied by the ulnar nerve, but in a small number, as Kinnier Wilson (1913) pointed out, wasting may be confined to the outer thenar muscles. In these cases, however, pain is usually present on the ulnar side of the forearm and hand and if sensory impairment is present it is commonly in ulnar rather than in median distribution. The abnormal rib will be shown on radiological examination but it must be remembered that symptomless cervical ribs are common and a carpal tunnel compression may occur in a patient who has a symptomless cervical rib.

The axillary inlet or thoracic inlet syndrome with compression or stretching of the lower trunk of the brachial plexus and the subclavian artery and vein as they pass from the neck into the axilla raises a difficult diagnostic problem. Before the clinical picture of carpal tunnel compression was clearly defined the majority of patients with acroparaesthesiae were thought to be suffering from this syndrome, but many developed clear-cut evidence of a median nerve compression later although they had been temporarily relieved by shoulder girdle exercises or operations on the neck It is now realized that the axillary inlet syndrome is a rare cause of acroparaesthesiae. In patients who have it paraesthesiae are predominantly in the little and ring fingers associated with drooping of the shoulder girdle, and if there are objective sensory changes these are in root distribution and are on the ulnar side of the hand and not in the distribution of the median nerve. Symptoms of carpal tunnel compression may be aggravated by drooping of the shoulder girdle as a result of diminished blood supply through the subclavian artery—the same mechanism as in the tourniquet test (*see* above)—and the improvement which may follow shoulder girdle exercises results from correction of this shoulder girdle droop.

Cervical disc protrusions

Paraesthesiae in the thumb, index and middle fingers with slight sensory impairment may accompany involvement of the sixth or seventh cervical roots by a lateral intervertebral disc protrusion. Here there is usually severe pain radiating down

the outer side of the arm and forearm which is aggravated by movements of the neck. In the majority of cases there is other evidence of cervical root involvement, wasting and weakness of the biceps with impairment of the biceps and supinator jerks in the case of the sixth root, and wasting of the triceps and impairment of the triceps jerk in the case of the seventh root. In the acute stage there should be no difficulty in diagnosis but paraesthesiae may persist for some weeks after pain has stopped and in these cases, if history taking is inadequate and unless the arm jerks are examined, a mistaken diagnosis of a carpal tunnel syndrome may be made.

PATHOGENESIS

The carpal tunnel lies between the transverse carpal ligament anteriorly and the bones of the wrist joint posteriorly and contains in one compartment the median nerve and the tendons of the finger flexors and in a smaller compartment the tendon of flexor carpi radialis. In some patients at operation the median nerve appears normal but in others there is compression of the nerve where it passes under the ligament and swelling of the nerve for an inch or so above this. The cause of the symptoms appears to be ischaemia of the nerve due to compression in the confined space of the carpal tunnel. With local lesions such as arthritis of the wrist or malunited fractures where the space within the carpal tunnel is reduced it is easy to understand compression occurring. In the majority of patients, however, no such space-occupying lesion is present. Brain, Wright and Wilkinson (1947) showed by experiments with a simple tambour inserted into the carpal tunnel that the space within the tunnel is reduced during extension of the wrist, and it seems probable that repeated extension of the wrist is an important factor in causing ischaemia of the median nerve; in older patients degenerative vascular changes may aggravate the effects of ischaemia Another possible factor is transient oedema of the soft tissues in the neighbourhood of the nerve (Kremer and his colleagues, 1953). This may explain the nocturnal symptoms in many patients if the venous return is partially obstructed by the patient lying on the arm while asleep. The occurrence of symptoms during pregnancy may also be due to oedema associated with water retention. There is at present no convincing explanation for the diffuse pain in the forearm, and sometimes extending as high as the shoulder, which occurs in some patients with carpal tunnel compression. This pain is relieved by operation on the transverse ligament, and also by splinting the wrist.

TREATMENT

Conservative treatment

Conservative treatment of acroparaesthesiae is indicated in the earliest cases where the symptoms have been of only a few weeks' duration and in pregnancy where a spontaneous remission is the rule after delivery. When there is an acute inflammatory swelling in the region of the wrist splinting is also helpful and the paraesthesiae will usually remit when the swelling subsides. If operation is for some reason contra-indicated, splinting of the wrist joint also affords a satisfactory alternative.

The splint may be made of a plastic material or of plaster of Paris and it is important that hyperextension of the wrist joint should not occur. A straight splint, or one with only a few degrees of extension, is usually satisfactory. Patients are advised to wear the splint for 2 or 3 weeks and then experiment to see if the symptoms recur when they leave it off.

Other types of conservative treatment are not so satisfactory and a change of employment should not be advised in a condition which is so readily alleviated by splinting or operation Shoulder girdle exercises may be helpful, but the results seem less satisfactory than from splinting.

Operation

In all cases of definite nerve compression with the sensory and motor changes of median nerve distribution, operation offers the patient a permanent cure There are very few contra-indications to operation, and even in advanced cases where hope of complete cure cannot be offered a relief of symptoms generally occurs. Failures of operation are usually due to failure to divide the transverse carpal ligament completely, usually in its distal part Operation is also curative in acro-paraesthesiae as shown by Kremer and his colleagues (1953), Garland, Bradshaw and Clark (1957), and Heathfield (1957).



FIG. 94 —Appearance of the median nerve after complete [illegible]

of compression.

Operative technique

The limb is exsanguinated with an Esmarch bandage and a pneumatic tourniquet inflated on the arm The incision begins 1 centimetre proximal to the distal flexion crease at the wrist and continues on to the palm for a distance of 3 centimetres, skirting the medial border of the thenar eminence. A transverse incision at wrist level does not provide adequate exposure of the distal part of the carpal ligament and, in practice, the longitudinal incision heals readily and no disability has followed transgression of the flexion creases. The deep fascia is incised in the



FIG. 95 —Longitudinal section through the hand The transverse carpal ligament has been coloured black and is shown thinning out to become continuous with the palmar aponeurosis.

proximal part of the wound and the median nerve is readily identified after retraction of the palmaris longus tendon. The nerve is followed to the proximal edge of the carpal ligament and division of this structure is begun, keeping rather to the medial side of the nerve and thus avoiding damage to the thenar motor branch which may curve back anterior to the carpal ligament. The ligament is divided under direct vision in a piecemeal fashion working from proximal to distal. It retracts considerably as it is divided and the underlying nerve can be clearly seen at all times (Fig. 94). It is of particular importance that section of the ligament is complete and division should be carried distally until the much thinner palmar aponeurosis is identified (Fig 95). It is unnecessary to disturb the median nerve itself and indeed close dissection of this structure in the palm may interfere with a plexus of nutrient blood vessels which it receives at this site When the carpal ligament has been completely divided the subcutaneous tissues are approximated with a few buried sutures The skin incision is then closed with fine vertical mattress sutures and a well-padded pressure dressing applied before the tourniquet is released. There is often greater post-operative comfort if the wrist is immobilized on a plaster back slab. The arm is kept elevated for 24 hours and the patient may then be discharged to the out-patients department.

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ABSTRACTS RELATING TO NEUROSURGERY

THE MANAGEMENT OF ACUTE HEAD INJURIES

Post-concussion syndrome

SELETZ (1957) reviewed cranio-cerebral injuries and the post-concussion syndrome. A patient with the post-concussion syndrome, although normal for weeks after injury as judged by gross neurological tests, will complain of headache and fatigue The symptom complex comprises bouts of severe headache or hemicrania and vasomotor exhaustion The headache may begin in the suboccipital region, radiating to the vertex or behind one eye; it may be frontal or temporal extending over the vertex to the occiput The author believes that this originates in the upper cervical nerve roots, in elements of the trigeminal nerve, or in both The symptom complex is designated the craniocervical syndrome Concussion incurred in a moving vehicle always produces unnatural rotation or sprain [illegible]

Sensory changes extending over the trigeminal facial area after whiplash injuries of the neck are explained anatomically by communications between branches of the cervical plexus and the trigeminal nerves and by occipital-trigeminal relations The vasomotor [illegible]

narrow escapes manifest all the symptoms of stress and shock.

Salt retention and uraemia

[illegible]

the trunk and extremities, suggesting trophic changes following the cerebral injury. There were no definite localizing neurological signs. Radiographs revealed a linear fracture of the left parietal bone involving the base of the sphenoid. The urine had specific gravity 1018; sugar and protein were absent. Dehydration was combated with intravenous fluid for 15 hours The blood urea was persistently raised until death occurred on the tenth day serum sodium and chloride, however, began to fall on the sixth day. There was no corresponding increase in the consistently low urinary levels of these electrolytes The serum potassium, although initially high, remained normal until it fell 2 days before death. Despite continuous fluids by vein or intragastric drip, the patient's condition slowly deteriorated. On the fourth day a trace of protein appeared in the urine, followed by pyuria and haematuria. Antibiotic treatment failed and death ensued. Necropsy revealed a fine crack in the left temporal bone, slight haemorrhage into the sphenoidal sinus, flattening of the cerebral convolutions and softening in the right temporal lobe. The lungs were congested and slightly oedematous, showing early bronchopneumonia. The renal cortex and medulla were pale, the distal tubules dilated. The histological changes, however, were small. That the brain damage is causally related to the metabolic changes is generally accepted, but the mechanism of the biochemical derangement is debatable. Although the role of the kidneys has not been sufficiently assessed, uraemia appears to be an integral part of the disturbance In this case the return of electrolytes to normal despite the low urinary content of sodium chloride suggests an internal shift or redistribution Neither dehydration nor diabetes insipidus was the responsible factor in the salt-hoarding of this case.

Mortality

Role of respiratory insufficiency

MACIVER, FREW and MATHESON (1958) discussed the role of respiratory insufficiency in the mortality of head injuries. Anoxia, consequent upon this condition, is the main cause of death in patients surviving the original injury. Immediate and adequate oxygen supply and treatment of chest complications are therefore essential for survival, the ultimate issue depending upon the degree and duration of anoxia. In severe injuries, damage to the pons, medulla and hypothalamic areas depresses respiratory-centre control, while damage to the vagal nuclei impairs control of the larynx and pharynx. At the same time, there is reduction of compliance of the lungs by blockage and irritation of the bronchial tree by aspirated material and retention of the mucus Treatment therefore is directed against anoxia and lung damage by full oxygenation in a chest kept clear of infection. The "tonsil" or prone position prevents seepage into the lungs and tracheobronchial tubes Temporary intubation is valuable, but early tracheotomy is preferable and should be performed on all deeply unconscious patients. It must be followed by continuous aseptic suction Daily bronchoscopy and chest radiography are essential It is before reaching hospital, however, that the patient is in most danger. Often unattended in the ambulance, he is lying flat on his back allowing foreign material free access to the trachea On arrival at hospital, suction and oxygen are imperative. If he is to be further transferred, intubation should be considered, this may obviate the necessity for tracheotomy and prevent anoxia

Acute renal failure

Management

TAYLOR (1957) described the management of acute renal failure following surgical operation and head injury It is diagnosed clinically by oliguria, proteinuria, low urinary specific gravity, and a rising blood-urea level. These symptoms, however, with coincident hypotension may occur in patients who do not develop acute renal failure Furthermore, oliguria is absent in one-third of confirmed post-traumatic cases, and this delays diagnosis until uraemia and hyperkalaemia become manifest Even when unequivocal oliguria exists, acute renal failure may be overlooked in unconscious patients with incontinence whose urinary output cannot be accurately measured Acute renal failure is therefore said to occur when the blood-urea level rises above 100 milligrams per 100 millilitres and the urine-urea level falls below 2 grammes per 100 millilitres in patients without previous renal disease. When the blood-urea level is higher than 100 milligrams and the urine-urea

level higher than 2 grammes, patients respond to simple adjustments of diet and fluid intake A urine-urea level below 2 grammes, however, is usually associated with other evidence of renal damage. Three cases are described Acute post-operative and post-traumatic renal failure must be differentiated from other coincident renal disease and

was found in 3 patients; thrombosis of the inferior vena cava was found in 2. Of the 31

PROGRESS IN NEUROSURGERY

Cerebral angiography

Role in a neurosurgical service

DIMANT, MOXON and LEWTAS (1956) wrote on the part played by cerebral angiography in the neurosurgical diagnosis of 1,007 patients. By increasing the number of out-patient

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angiographically. In a further ... there was no visible thrombosis, but the radiological
features of arteriosclerosis were commonly seen In a further 3 the degree of deformity
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cases of doubt air studies are needed Only
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safe diagnosis of emergencies Benign can

and the pathological type of tumour was correctly diagnosed in 39 per cent of the cases. Accurate localization was given in 74 per cent of the brain tumours and in a further 14 per cent their presence was indicated.

Intracranial tumours

Cranial radiography

GRIFFITHS (1957) described observations on a series of plain films of the skulls of patients with verified intracranial tumours. Of the cases reviewed, plain films of the skull gave definite evidence of an intracranial tumour or raised intracranial pressure in 282; in a further 87 cases evidence was strong but not definite. Radiographs have shown *inter alia* changes in the sella turcica, and 141 cases had an abnormality of the sella; this was present more than twice as often as any other sign. The next most helpful sign numerically was pineal displacement. In an absolutely symmetrical skull, positioned to avoid rotation and with the central ray passing through the sagittal plane, any deviation of the pineal from the mid-line must be regarded as abnormal. Displacements of the choroid plexus were seen in only a few instances in the whole series. There were many examples of calcification in the falx without displacement, in association with tumours in a variety of positions. Changes in the vascular grooves and channels were not always identifiable and only a few cases were seen in which high pressure was sustained over a

[illegible]

chest. In several of these the autopsy showed a bronchial neoplasm. The author realizes the review is incomplete and further studies are proposed.

Encephalography and ventriculography

NORLÉN and WICKBOM (1958) discussed the relative merits of air encephalography and ventriculography for the investigation of intracranial tumours. The authors have obtained a series of 327 cases which have been uniformly treated in an endeavour to draw as definite conclusions as possible about the risks and value of the methods. The cases have been divided into 205 supratentorial tumours, 75 infratentorial tumours, and 2 pinealomas. Of the 205 cases of supratentorial tumour (45 suprasellar tumours having been excluded) 101 presented with choked discs. These tumours were mainly gliomas and meningiomas. The ventricular system was incompletely filled with air in 23 cases out of 114 in which encephalography was performed. In only 19 cases had ventriculography to be undertaken. Of the posterior fossa tumours one group of 29 cases was composed of cerebellopontine angle tumours and tumours of the clivus, 12 presenting with choked discs. Encephalography, performed in 22 cases, was negative in only 2. In 5 cases the air study was incomplete inasmuch as no air entered the ventricular system, but the tumour was outlined by air in the basal cisterns. Of the other group of 36 cerebellar tumours, 30 presented with choked discs and 32 encephalograms were performed. In 4 cases no air study was done, in 6 cases where the air had not entered the ventricular system, cisternal ... had to be per- ... was ... that with the technique used encephalography can and should be performed in practically every case where an air study is indicated. Even in those cases where ventriculography is necessary for the examination of the ventricular system, encephalography is often of great value and should be performed as a first procedure.

Spontaneous subarachnoid haemorrhage

Vertebral arteriography

SPATZ and BULL (1957) wrote on the use of vertebral arteriography in a series of 60 cases of spontaneous subarachnoid haemorrhage in which bilateral carotid arteriography

did not reveal a source of bleeding. No cases were included in which a posterior fossa lesion was suspected and diagnosed by vertebral arteriography as a primary procedure. In no case was there an apparent haemorrhagic diathesis, and none of the patients had suffered craniocerebral injury. Vertebral arteriography was entirely percutaneous via an anterior approach. In 16 cases the procedure demonstrated a lesion capable of producing, and assumed to be responsible for, the subarachnoid haemorrhage. Eight were aneurysms and 8 angiomas Clinically, 9 patients exhibited hypertension as judged by several recordings of diastolic pressure over 90 millimetres of mercury. Thirty-seven patients retained consciousness while 23 patients lost consciousness initially or in the early stages of their illness. In all but 1 case the main symptom was severe headache.

[illegible]

Both posterior cerebral arteries must be filled to exclude supratentorial angiomas and aneurysms.

Isotope encephalometry

Review of basic data

Basic data in isotope encephalometry were reviewed by FRENCH and CHOU (1957) In the early stages of the development of isotope encephalometry, Geiger-Müller tubes were used to pick up radiation In these, as the detection substance is a gas, very few of the gamma radiations strike a gas molecule because the density of the gas is low and an average Geiger-Muller tube detects only 1–2 per cent of γ radiation. Scintillation counters are more effective as the detecting substance is a solid crystal, and detects as many as 60 per cent of γ radiations The fundamental principle of isotope encephalometry is the relative concentration of the radioactive substances in pathological as compared to normal brain tissue The concentrating materials in common use have been: (1) biiodofluorescein labelled with ^{131}I (DIF)—a γ emitter that concentrates up to 1 in 10 in tumour tissue (this substance has now been replaced by others for various reasons, including its rapid drop in blood and tissue levels); (2) radioactive iodinated human

[illegible]

tion of a focus They conclude that the techniques have not been exhausted and estimate that an accuracy of 65–75 per cent for the localization of brain tumours can be obtained routinely.

Hypothermia

Interruption of carotid or carotid and vertebral circulation

BOTTERELL and his colleagues (1956) discussed hypothermia and interruption of carotid or carotid and vertebral circulation in the surgical management of intracranial aneurysms. In the authors' technique, pre-operative clinical assessment is followed by electro-

[illegible]

chlorpromazine and promethazine are used to produce sedation, to potentiate other

analgesics and anaesthetics, and to aid the production of hypothermia. One lead of the electroencephalograph is used for continuous electroencephalographic recording. A thermometer is inserted into the rectum and deeply into the muscle of the thigh. In the presence of a palpable pulse in the ulnar artery a Cournand needle is inserted into the radial artery and connected to an aneroid manometer. Hypothermia is induced in 3 stages: the first drop in temperature results from the pre-operative sedation with chlorpromazine, promethazine and Demerol; the second stage is concomitant with the cervical dissection; during the third stage cooling of the legs and trunk is carried out in a bath on the operating table using ice water. On completion of the intracranial procedure rewarming is begun if the rectal temperature is below 30° C or if it is above 30° C and still falling. During operation the common carotid and vertebral arteries are exposed bilaterally using a transverse incision at the level of the cricoid cartilage. Post-operatively a dangerous degree of systemic hypotension may occur, necessitating administration of norepinephrine; as it may be impossible to puncture superficial veins in the hypothermic patient the continued efficiency of an intravenous drip must be ensured. Any respiratory difficulty post-operatively has been an indication for immediate tracheotomy. The authors have operated upon 22 patients with berry aneurysms at varying intervals after rupture of the aneurysm using hypothermia; there were 3 deaths. One patient with an unruptured aneurysm died following operation. The results were classified as excellent or good in 16 of the 19 survivors, fair in 1 case and bad in 2 cases. The reduction of cerebral blood flow was achieved by bilateral occlusion of cervical vessels in various combinations. The method proved to be very valuable in cases in which the aneurysm was ruptured, and allowed accurate identification and clipping or ligation of the aneurysmal neck. The electroencephalographic changes observed post-operatively were similar to those observed in similar operations without hypothermia. The appearance of delta activity during operation has been used as a guide to the maximum time for which it is safe to occlude the vessels supplying the brain. In only 1 of the cases was there clinical or electroencephalographic evidence of local or general cerebral injury attributable to anoxia from interruption of the cerebral circulation, but the authors' purpose has been to minimize the duration of bilateral carotid and vertebral occlusion, although the course may be dictated by severity of bleeding and technical difficulties. It appears that in human beings the maximum period of common carotid or carotid and vertebral occlusion at 30° C in a healthy individual of middle age or younger should not exceed 6 minutes, and at 28° C should not exceed 8 minutes; the period of safety varies and the best determinant is the electroencephalogram.

Intracranial meningiomas

Recurrence after surgical treatment

SIMPSON (1957) wrote on the recurrence of intracranial meningiomas after surgical treatment, and analysed the results of a study of 2 series of these lesions. Two hundred and forty-two patients were treated between 1938 and 1954, cases of spinal and primary intraorbital meningiomas have been excluded. Another series of 97 cases treated between 1928 and 1938 have been considered as providing examples of survival for more than 17 years, but there have been difficulties in follow-up and only limited use has been made of them. All of the first mentioned series have been followed-up. Of these 235 came to operation. Thirty died within 6 months, but this figure exaggerates the operative mortality as a few died from intercurrent disease or continued growth after discharge from hospital. Five distinct grades of operation have been identified. In Grade I, macroscopically complete removal of the tumour, there were 81 primary operations and 9 operations on recurrent tumours. There were 8 recurrences (9 per cent). In Grade II, in which the visible tumour was totally removed but its dural attachment merely coagulated with the endothermy cautery, there were 18 recurrences (19 per cent), if the cases treated in the last 5 years are excluded. The average time elapsing before confirmation of recurrence was 59 months, the extremes being 13 years and 26 months. The remaining operations of Grades III, IV and V cannot be considered to have been radical. They were, respectively, a macroscopically complete removal of the intradural tumour without resection or coagulation of its dural attachment, or, alternatively, of its extradural extensions; a

20 recurrences, mostly fatal, giving a recurrence rate of 39 per cent or 44 per cent if cases treated in the last 5 years are excluded. Thirteen patients have lived 10 years or more; 9 of these passed 15 years. In Grade V simple decompression alone may sometimes prolong life and in a few cases it was resorted to because of torrential bleeding. Nine patients survived more than 6 months and 2 lived for 7 and 9 years respectively before developing symptomatic recurrences After operations in Grades III-V the incidence of recurrence is naturally much greater, but patients so treated have been given long periods of relief. Clinically, meningiomas may be benign, locally invasive or malignant. Infiltration of venous sinuses was found in 15 per cent; of bone in 20 per cent and of brain in 3·7 per cent. Haematogenous metastasis was seen in 2 patients The chief causes of recurrence appear to have been unnoticed invasion of a dural venous sinus, and unsuspected spread across a free dural septum. Detached nodules of tumour, fragments of the subdural fringe often seen in meningiomas, infiltration of bone and the presence of multiple primary tumours are other causes of recurrence. In the average case recurrence may always be possible, and sustained watchfulness is needed.

Pearly tumours

In relation to the central nervous system

TYTUS and PENNYBACKER (1956) discussed pearly tumours in relation to the central

dence ra[illegible]
system. [illegible]
series cc[illegible]
patients [illegible]

groups. Although removal was incomplete in at least 12 of the present series, known recurrence has taken place in only 2 of these cases; 2 others may be showing signs of recurrence, the remaining 8 have been followed for an average of 8 years.

Rathké-pouch tumours

NORTHFIELD (1957) wrote on Rathké-pouch tumours and described a series of cases admitted to hospital since 1934. There were 26 males and 23 females; the ages ranged

from 3 to 56 years. Operations have been done on 38 patients, with 18 deaths. Six are known to have died later, probably from effects of the tumour, and the outcome is uncertain in 5 untraced; 9 are known to be alive. Headache and vomiting were the presenting complaint in 23; failure of vision in 22, diplopia in 2; dementia in 1, and epilepsy in 1. Papilloedema occurred in 20 and primary optic atrophy in 19; chiasmal compression was present in 26, and 7 patients were virtually blind. Mental deterioration in some was too severe for examination of the visual fields. In only 3 were the optic pathways clinically normal. Clinical evidence of endocrine disturbance was found in 31; disturbance of sexual function occurred in 24, and of growth in 18. In 15 cases blood pressure was unusually low, maintaining pressures varying from 100/70 millimetres of mercury to 85/50 millimetres of mercury. The author considers that depression of the blood pressure occurs more frequently in Rathé-pouch tumour cases than in those of pituitary adenoma with comparable endocrine failure. The explanation may be the direct involvement of the hypothalamus Radiography is an essential aid in diagnosis and before operation ventriculography or encephalography is necessary to decide on the site and extent of the lesion In a detailed analysis of part of the series there were 46 operations on 32 patients, with 16 deaths In some extirpation was attempted, but when this procedure was too dangerous fragmentary removal was made for histological examination or to collapse a cyst; in others, Torkildsen's ventriculocisternostomy was performed to relieve hydrocephalus In some patients as many as 3 operations have been performed and followed by relief of symptoms for some years. Analysis has shown that transventricular operations carry a high mortality, this is considered to be evidence not so much of any technical hazard of the operation, but rather of the dangerous site of the tuberal tumour with its third ventricle extension. The author reserves radical operations for intrasellar and subtuberal tumours. In the case of the former, operation should not be deferred, as delay makes for difficulty and danger. Subtuberal tumours should be explored knowing they may involve the tuber; total extirpation may then be fatal, while leaving a remnant may preserve life for years. On the facts of post-mortem examination the tuberal or intrinsic tumour is essentially irremovable. Treatment of Rathké-pouch tumour has been fraught with difficulty and disappointment to a degree probably not offered by any other intracranial tumour, excepting the glioblastoma Hormone therapy should be employed where investigation shows need during the period of operation, but there is little evidence that it can influence the disastrous reaction resulting from operative trauma in the hypothalamus.

Neurofibromas of the fifth cranial nerve

OLIVE and SVIEN (1957) reviewed 13 cases of solitary neurofibromas (neurilemmomas) of the fifth cranial nerve. In 6 cases the tumours were restricted primarily to the middle fossa, in 4 to the posterior fossa, and in 3 they were situated both supratentorially and infratentorially. In the group of supratentorial tumours, one case presented as a chiasmal lesion; in another case, where a tumour arising in the middle fossa eroded the petrous bone, clear-cut symptoms of a tumour of the cerebello-pontine angle were present; in a third case symptoms suggested a tumour of the middle fossa, both the fifth and ipsilateral optic nerve being involved, and the diagnosis was confirmed by radiological findings. Symptoms referable to the fifth nerve predominated in a fourth case; the onset of facial paraesthesia, followed by severe facial pain, facial analgesia and weakness of the masticatory muscles, pointed to involvement of the middle fossa. Pain within the ear was the initial complaint in the fifth case; involvement of the fifth nerve and radiological changes pointed to the lesion in the middle fossa. In the sixth case a tumour 2·5×2·5×2 centimetres was present in the gasserian ganglion without any symptoms or signs of involvement of the middle fossa Of the supratentorial and infratentorial tumours, symptoms and signs referable to the posterior fossa predominated in 2 cases; in the other a tumour was removed from the middle fossa after the posterior root of the trigeminal nerve had been sectioned and reflected A further operation 5 years later revealed tumour in the posterior fossa. In the 4 infratentorial tumours all had symptoms and signs of involvement of the posterior fossa. In 3 signs of involvement of the fifth nerve were followed by findings referable to involvement of the eighth nerve and cerebellar involvement. In 1 case symptoms and signs suggested pseudobulbar palsy, but were predominantly unilateral. Ataxia

was a common feature observed from study of the gross specimens removed at operation and at post-mortem examination In all cases the tissue was identified as neurofibroma by the use of routine and special stains.

Gliomas of the optic pathways in childhood

FOWLER and MATSON (1957) wrote on glioma of the optic pathway in childhood,

exception of 2 patients who had had previous surgical treatment the authors have used a

Astrocytoma

Long-term follow-up

ELVIDGE and MARTINEZ-COLL (1956) wrote on a long-term follow-up of 106 cases of

were 7 operative deaths and 3 cases where the post-operative course was unknown. In the 19 cases followed-up, 7 died within the first year after operation, 3 within the third

post-operative year, 1 died 5 years after operation, and 8 survived for over 8 years: an average post-operative survival of 5 years and 4 months. In most cases it was not possible to remove the whole of the tumour, but partial removal and decompress... followed by rad otherap...

...tumours. In the non-cystic group the average post-operative survival was 3 years and 9 months, and the cystic group, 2 years and 9 months, suggesting that cyst formation in the gemistocytic group does not necessarily mean a slower rate of growth th...
the cerebrum. There we...
was the cerebral hemisp...
in 8, and 8 in the brain ...m, third ventricle and spinal cord. Cyst formation was present in 26 cases Epilepsy was present in 18 cases with location in the cerebral hemisphere Twelve operative deaths occurred, and 39 cases were available for follow-up. Of these 12 survived less than 2 years, 8 died within the second and fifth post-operative years and 19 survived more than 5 years after operation, up to 23½ years. The longest survivals were, in those of tumour of the cerebral hemisphere and in the cerebellar mid-line and hemisphere.

Brain tumour

Use of tantalum powder as an indicator

Lindgren, Löfgren and Lundberg (1957) described the use of tantalum powder as an indicator of the brain tumour region for post-operative radiotherapy and the diagnosis of recurrence. The size of the particles of tantalum powder used was 8–12 μ (325 mesh); the powder was stirred to a thick paste with normal saline and the surface to be demonstrated was then covered with a thin layer of the paste. In some instances the powder was spread over very thin slices of Oxycel and these were placed on the surface to be indicated In a few cases in which verification of the tumour was obtained by means of diagnostic puncture, a small quantity of the paste was deposited via the cannula at the site from which tumour tissue had been aspirated. The method has been used in 25 cases as a guide for post-operative radiotherapy, which was planned on the basis of pre-operative radiography combined with the post-operative radiograph in which the powder indicated the site of any remaining tumour tissue. This enabled the radium beam to be focused on t...
A group of I...
rence; 10 of...
have been fol...
situated in the frontal region, the recurrence was verified by encephalography and at...

signs of recurrence.

Pituitary adenoma

Treatment

Horrax (1958) wrote on surgery versus radiation in the treatment of pituitary adenomas. In a total series of 1,963 brain tumours seen at the Lahey Clinic up to the end of 1955 there were 335 adenomas, representing 17 per cent of all tumours. In the early part of this century surgery was the only known treatment capable of reducing the size of pituitary ... eration reduced the rate of recurrence. ... treat these lesions solely by irradiation ... rotational method and giving a larger

mour dose, namely, 4,000 r. It was soon found that patients did well and surgical

ılarged sella turcicas, as well as other pituitary stigmata Before the employment of the gher dosage in 1950, 62·9 per cent of patients receiving primary irradiation had to be ›erated upon subsequently. In the more recent period, 1950–55 inclusive, 66 patients ith visual loss received primary irradiation with the high-volt apparatus. So far only

ıused damage to that portion of the brain in proximity to the growth.

Iydrocephalus

Irinary phenolsulphonphthalein excretion test

The urinary

escribed by L

nd the dye is estimated within 24 hours Estimation of the dye is made in a photo-lectric colorimeter using centrifuged alkaline urine as a blank and phenol red as a tandard. The data are considered under 4 anatomical groups: (1) normal cerebrospinal luid pathway; (2) basal cistern block; (3) intraventricular block, and (4) spina bifida

space. The method has been of value as an adjunct to good pneumoencephalography; it could replace poor radiographs and gives additional information when there is a combined ventricular and basal cisternal block It may eventually be found valuable in prognosis

Thrombosis of the internal carotid artery

Treatment by arterial surgery

appealing theoretical advantage of direct arterial surgery is the chance to interrupt a chain of
some of
of partia

occlusions occur elsewhere in the cerebral arterial system. The authors point out certain risks in the treatment; for example, clamping the carotid arteries might cause ischaemic cerebral necrosis. Another potential cause of cerebral ischaemia is hypotension due to anaesthetic agents or haemorrhage during surgery. A further possible complication is the production of an embolus from the operative site, or the production of intracerebral vascular spasm secondary to the operative trauma. Provided, however, that routine prophylactic measures are taken these theoretical complications should prove uncommon in practice. The use of hypothermia may be important. The procedure of choice is thromboendarterectomy and a localized resection with end-to-end anastomosis is the next most desirable procedure.

Cervical spondylosis

BRADSHAW (1957) stated that occupational stress does not predispose to generalized cervical spondylosis. If spondylosis exists, however, the stress may increase the liability to neurological complications. On the other hand, it appears that focal spondylosis is

Signs referab
neck movem
upper limbs,
lopathy associated with cervical spondylosis is probably seldom due to direct compression of the spinal cord and may often be due to vascular changes, so that the neurological complications may be mistaken for other diseases. Investigation reveals that in the absence of a manometric abnormality the amount of protein in the lumbar cerebrospinal fluid may be increased to 120 milligrams per 100 millilitres. Myelography may show a
... due to the spinal cord.
With regard to
may result when

6–18 months.

THE CARPAL TUNNEL SYNDROME

Electrical signs in diagnosis

SIMPSON (1956) discussed electrical signs in the diagnosis of carpal tunnel and related ... presumed to be a local

segment and repetitive firing of motor nerve fibres after a single shock stimulus. Seventeen patients were examined, 2 of whom had ulnar nerve lesions. Ten normal subjects, 5 patients with motor neurone disease and 10 with various muscular diseases acted as controls. In 11 of 15 cases of carpal tunnel syndrome, slowed conduction was demonstrated in the presumed ischaemic section of the median nerve. After operative decompression of the

Acroparaesthesia and the carpal tunnel syndrome

HEATHFIELD (1957) discussed acroparaesthesiae and the carpal tunnel syndrome.

patients, only by day in others; some cases were worse at night, others by day. Sensory loss was more frequent than motor. In one-third of the cases there were no abnormal

in the aetiology of acroparaesthesia.

Acroparaesthesia

Clinical features

patients Patients often experienced the first symptoms during the night, when pain and

provoked in 3 patients when digital pressure was applied to the volar aspect of the wrist.

ligament was found to be swollen. In 11 cases the portion of the nerve under the ligament presented a flattened appearance. Symptoms were relieved by the treatment and normal activity was restored. In contrast, less satisfactory results were obtained when medical treatment was employed in the management of a series of 18 cases. For instance, 7 patients belonging to this series continued to experience nocturnal attacks of pain and paraesthesiae.

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GLAUCOMA

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Glaucoma is a condition in which the intra-ocular pressure is raised above a normal level.

PHYSIOLOGY

The intra-ocular pressure depends on the balance between the formation and drainage of aqueous humour in the eye. Aqueous is formed by secretion from the ciliary body into the posterior chamber—the small space between the posterior surface of the iris and the anterior surface of the lens. It then flows through the pupil into the anterior chamber from whence it leaves the eye by passing through the trabecular meshwork at the angle of the anterior chamber into the canal of Schlemm. The canal of Schlemm has numerous outlet channels through which aqueous flows into the episcleral venous network and the conjunctival veins.

Examination by means of a slit-lamp microscope will show, in most normal eyes, one or more conjunctival vessels containing a stream of clear fluid. This is aqueous humour and these vessels are known as aqueous veins (Fig. 96).

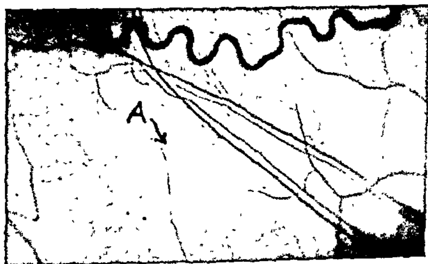


Fig. 96.—Photograph of an aqueous vein.

(By courtesy of the Editor, *British Journal of Ophthalmology*.)

The height of the intra-ocular pressure depends on the relationship between the rate of formation of aqueous and its rate of drainage from the eye, and is normally in the region of 20 millimetres of mercury. It is very difficult to set exact limits for the normal pressure as it can be measured reliably only by manometric methods involving direct cannulation of the eye. This is obviously not a practical routine method and clinically we must be content with estimating the tension in the coats of the eye.

Tonometry

The most commonly used instrument is the Schiotz tonometer which measures the degree of indentation of the cornea produced by resting on it a plunger of known weight. The indentation will depend on the tension in the ocular coats, but the intra-ocular pressure is only one of the factors which control this tension, and although such tonometric methods are very helpful they must always be interpreted cautiously where individual eyes are concerned. Comparative readings on the same eye will give a reliable intimation of any change in intra-ocular pressure, but although the result is expressed in millimetres of mercury such an apparently scientific expression is spurious and may be misleading when applied to an isolated measurement. There is considerable interest in improving tonometric methods at the present time and it is probable that more reliable and accurate methods will soon be available. The applanation tonometer of Goldmann (Goldmann and Schmidt, 1957) overcomes some of the disadvantages of other methods and probably gives readings nearer to the true pressure.

Theoretically, glaucoma may be due to overproduction of aqueous or to a decrease in its drainage from the eye. In practice, hypersecretion is uncommon and most types of glaucoma are due to some obstruction to outflow of aqueous.

CLASSIFICATION

It is usual to divide glaucoma into primary and secondary—the latter group consisting of those cases of raised tension resulting from some other disease process in the eye. For example, as a complication of inflammations of the iris, the pupil may become occluded by exudate and stuck firmly to the anterior surface of the lens so that the aqueous cannot flow from the posterior chamber into the anterior chamber. The intra-ocular pressure therefore rises. In primary glaucoma, on the other hand, the raised pressure has not such an obvious cause, and this group will be considered first.

[illegible] two [illegible] f the [illegible] e iris and the angle of the anterior chamber cannot be seen directly in the intact eye, but by the use [illegible] can be studied [illegible] examination is [illegible] matically in Fig. 97.

Normal eyes are found to show considerable variation in the anatomy of the angle In particular the root of the iris may be widely separated from the posterior surface of the cornea or there may be only a narrow space The width of the

"angle", as this distance is termed, is genetically determined in the main, but tends to become narrower as age advances due to slight swelling of the lens. Small, hypermetropic eyes tend to have narrow angles whereas large myopic or emmetropic eyes are more likely to have wide angles.

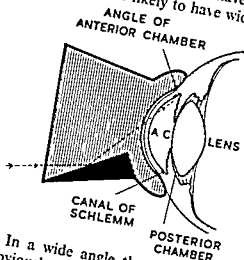


FIG 97—The optical principle of gonioscopy.

In a wide angle the trabecular meshwork can be clearly seen and there is obviously no hindrance to the access of aqueous to the angle, but in eyes with a narrow angle the iris is so far forward that it may be impossible to see the trabeculae, it is easy to appreciate that quite a small forward movement of the iris would bring it into contact with the cornea, and if this happened in the whole circumference of the angle the exit of aqueous would be completely blocked. This is, in fact, what happens in one type of primary glaucoma, and because in the attack of raised tension which follows the closure of the angle the eye becomes red and painful this type of glaucoma used to be known as congestive glaucoma. Now that the basic mechanism is understood it has been recommended by the Symposium on Glaucoma (1954)* that this disease should be known as closed angle glaucoma. The other type of primary glaucoma is not related to angle closure by the iris and is known as chronic simple glaucoma.

PRIMARY GLAUCOMA

Closed angle glaucoma

Aetiology

The first requisite for the development of this disease is an eye with a narrow angle. This almost invariably means an eye with a shallow anterior chamber, and as, to a great extent, these anatomical factors are genetically determined, it is not surprising that there may be a familial incidence of the disease. The swelling of the lens in advancing years aggravates the anatomical predisposition to a narrow angle, but even so, since there are many people with narrow angles who never develop glaucoma, there must be some other factor concerned in the patients who do. It has been suggested that congestion of the ciliary body from a variety of causes may be the initiating factor in the angle closure, while an alternative explanation

* Organized by the Council for International Organizations of Medical Sciences. Established under the joint auspices of U N E.S C.O. and W H O

is that in this type of eye the pupillary portion of the iris is held against the anterior surface of the lens with sufficient force to form some resistance to the passage of aqueous. If this happens the pressure in the posterior chamber rises and causes a bowing forward of the weak periphery of the iris until it comes into contact with the cornea and closes the angle. Whichever is the correct explanation, once the angle is closed the intra-ocular pressure rises rapidly and remains elevated until the angle opens This may occur spontaneously, as happens in early cases after rest or changes in the environment which cause the pupil to contract, or after medical or surgical treatment. During an attack of raised pressure the cornea becomes hazy and the blood supply to the optic nerve and retina is reduced. If the attack is of short duration the eye recovers with no loss of function, but repeated attacks or an attack lasting many hours or even days will result in severe visual loss due to ischaemia of the optic nerve.

Symptoms and signs

Typically the patient is in the 50–60 years age group, more commonly a female than a male and frequently of an over-anxious and excitable temperament. She will give a history of attacks of discomfort and perhaps pain in one or both eyes accompanied by blurring of vision. The attacks commonly occur in the evening, particularly under conditions of reduced illumination, and may be associated with emotional episodes. A visit to a cinema or watching television may precipitate an attack, and one patient, for example, developed an attack every time she played bridge. The patient may volunteer the information that during an attack there [illegible] other [illegible] due t[illegible] otherwise

The attacks in the early stages subside after resting or during sleep, but if untreated, sooner or later an episode occurs in which the occlusion of the angle is not relieved by rest and a full-blown attack of acute congestive glaucoma develops Diagnosis is then easy, but it is in the early stages when the angle opens spontaneously between attacks that the prognosis for treatment is most favourable and every effort should be made to detect the disease at this stage. Clinical diagnosis depends very largely on the history, as examination of the eyes may reveal no abnormality of visual acuity, visual fields or ocular tension. The anterior chamber, however, will be found to be shallow and gonioscopy will confirm the narrow angle. A positive family history is a great help.

There are special diagnostic measures which can be applied in doubtful cases and these take the form of provocative tests in which the conditions predisposing to congestive attacks are simulated and the behaviour of the ocular tension noted. For example, in a predisposed eye, careful dilatation of the pupil may cause the iris to bunch up in the periphery and result in closure of the angle. Sitting the patient in the dark for an hour may have a similar effect and cause a rise in tension greater than would be found in a normal eye.

The diagnosis of early closed angle glaucoma depends then on careful history taking, the realization that a shallow anterior chamber may be the only physical sign, and the result of provocative tests.

Treatment

Treatment is designed to prevent the root of the iris billowing forward to obstruct the angle. Constriction of the pupil by miotic drugs usually has the desired effect of preventing attacks, but it is not an absolute safeguard, and as a severe attack may have disastrous effects on the function of the eye there are strong arguments in favour of surgery as soon as the diagnosis is made. Certainly such a course is wise if the patient appears likely to be careless in using the miotic drops or is unable to be kept under regular supervision.

The operative treatment of early closed angle glaucoma is designed to prevent any difference in pressure between the posterior chamber and the anterior chamber by establishing a direct communication between them. This is achieved very simply by removing a small piece of peripheral iris tissue, and post-operatively it will be seen by gonioscopy that the tendency for the periphery of the iris to bulge forward —the so-called physiological iris bombé—has been abolished and provocative tests no longer cause a significant rise in ocular tension.

Such an operation is very simple and safe but can be employed successfully only if the major part of the angle is open between attacks and the disease has not progressed so far that there are many permanent adhesions between the root of the iris and the cornea. These adhesions gradually develop as the patient has repeated attacks in which a congested iris touches the cornea and thereby forms a permanent obstruction to outflow which persists between attacks. Such a condition may lead to a chronically raised intra-ocular pressure which will produce the optic atrophy and field changes found in chronic simple glaucoma Miotic treatment at this stage is unlikely to be successful and surgery is more difficult and attended by a much higher risk of complications. Thus, the slight risk involved in a peripheral iridectomy is very preferable to the establishment of a state of chronic angle-closure glaucoma.

Results of treatment

In assessing results of treatment it is convenient to divide the cases into three groups. Thus, in a recent analysis of some cases from the author's clinic there were 10 eyes which required immediate surgery for acute congestive attacks, 18 in which medical treatment averted immediate operation but in which surgery was subsequently necessary, and a third group of 33 eyes still receiving medical therapy. Most of the last group were patients with disease in the second eye, the other eye having been operated upon previously.

In the first group surgery was successful in controlling the tension in 9 out of the 10 eyes. The remaining eye was in a state of absolute glaucoma when first seen and prognosis was hopeless. The second eye of this patient was almost blind and has been treated medically, but the tension is poorly controlled and the outlook bad.

In the second group operation was successful after the failure of medical treatment in 16 out of 18 cases. Three of these developed post-operative lens changes but the tension has been controlled

The third group comprises mainly patients who have already had successful surgery in one eye and whose second eye has not shown evidence of congestive attacks on miotic therapy. Bain (1957) has recently studied the prognosis of such eyes and found that, excluding 7 cases who had undergone prophylactic operation,

53 per cent of 200 cases developed symptoms sooner or later in the second eye. One hundred and thirty-seven of these cases were on miotic therapy, but even so 39 per cent of them developed symptoms. Of 39 cases receiving no treatment 78 per cent developed trouble. It is clear, therefore, that miotic therapy, although better than no treatment at all, does not always protect the eye from further attacks. Six cases of the 7 which had had a prophylactic operation were completely controlled and the seventh was satisfactory for 25 years.

In the author's series 33 eyes have received medical treatment only, and of these 27 have so far been controlled, but in view of Bain's result it is likely that some of them will require surgery. Six eyes have not responded to medical treatment.

In 4 of these (2 patients) operation has been refused by the patients with tragic results. One is blind in one eye and has only perception of hand movements in the other eye; the second patient finally had one eye enucleated because of severe pain in a blind eye and the other eye has only 6/36 vision

Excluding the patients who refused operation, the prognosis in closed angle glaucoma is good—tension controlled in 51 out of 55 eyes—with the proviso that vision lost before treatment is effective cannot be restored.

Acute congestive glaucoma

This produces one of the most dramatic clinical pictures in ophthalmology. The mechanism is closure of the angle as previously described, but the angle fails to open spontaneously, the eye becomes more congested and the intra-ocular pressure rises to a high level causing severe pain and great diminution of vision as the circulation of the optic nerve and retina is impeded and the cornea becomes hazy and oedematous

Symptoms and signs

Careful history taking will usually elicit evidence of previous minor attacks, but the pain is so severe that it may reduce the patient to such a state that co-operation is poor; vomiting may occur and may even direct attention away from the ocular condition. Examination of the eye will reveal, first, that the vision is greatly reduced, perhaps to perception of light only, and this observation alone should be enough to emphasize the gravity of the condition. The conjunctiva appears a purplish red, but there will be no evidence of the mucopurulent discharge seen in a conjunctivitis. The cornea will no longer have its normal lustre but will appear dull and hazy, and through it will be seen the semi-dilated pupil, not reacting to light Fundus examination of this eye is usually impossible. A comparison of the ocular tension of the two eyes (by gentle palpation) will leave little doubt that the affected eye is very hard.

Differential diagnosis

The differential diagnosis is from a corneal ulcer, iridocyclitis or possibly conjunctivitis. A corneal ulcer causes a sharp stabbing pain accentuated by blinking but does not reduce the vision so severely as does glaucoma. The pupil will be contracted due to reflex spasm and the tension will be normal In iridocyclitis the pain is less severe and again the vision is rarely reduced so drastically as in glaucoma. The pupil tends to be contracted and reacts sluggishly, but the cornea is clear and the tension only slightly, if at all, raised. Conjunctivitis should never be confused

with these more serious conditions, but in practice still is. *Vision in superficial* infections of the eye is unaffected, except by temporary veiling due to mucus floating over the cornea, and the discomfort of a conjunctivitis bears no relation *to the pain of* acute glaucoma. The cornea is clear, the pupil reacts normally and the tension is not raised.

Medical treatment

An acutely congested eye in an ill patient means an undesirable operative risk, and medical methods are always pursued energetically in an endeavour to reduce the tension. Intensive treatment with eserine drops, 1 per cent, and local heat are used to contract the pupil, thus opening the angle and allowing the aqueous to drain away. Morphine is often valuable as a sedative and also because it causes miosis.

Recently a new drug has been found to lower the intra-ocular pressure of both normal and glaucomatous eyes. Diamox (acetazoleamide) is an inhibitor of carbonic anhydrase which has been used successfully as a diuretic. The exact manner in which it acts in the eye is not yet clear, but it is known that it does reduce the formation of aqueous humour from the ciliary body, probably by interfering with the transport of water into the eye It may be given intramuscularly in doses *of 500 milligrams in acute cases or 250 milligrams by mouth in less urgent* cases. Its effectiveness in lowering the intra-ocular pressure depends only on the reduction of formation of aqueous and it is therefore useful in both primary and secondary glaucoma. In acute congestive attacks, in combination with other medical or surgical treatment, it is very helpful in reducing the tension. It must be realized, however, that Diamox has no effect on the angle closure, and until the angle is open the attack has not been properly treated. The lowering of pressure brought about by Diamox may actually be disadvantageous for other reasons. *The relief from pain may encourage the patient to refuse surgery or, of more impor*tance, surgery may be delayed owing to the apparent improvement in the condition of the eye, although in fact the congested iris is still in contact with the posterior surface of the cornea. This contact, if allowed to continue, may develop into firm adhesions—peripheral anterior synechiae—which make subsequent *surgery more* difficult.

Unless medical treatment with Diamox and miotics is successful in opening the angle as well as in reducing the tension surgery should not be delayed; if medical therapy is going to be successful *it should have produced a marked decrease in* tension and good miosis within three hours.

Surgical treatment

General anaesthesia is preferable to local analgesia and the safest operation is a modification of the time-honoured von Graefe iridectomy. For this to be effective the root of the iris must be freed from contact with the cornea *and the original* corneal incision is better discarded in favour of a subconjunctival approach.

The lids are held open by a retractor and a stitch inserted beneath the superior [illegible] to fix the globe. The conjunctiva is grasped one centimetre away [illegible]

cornea and the subconjunctival tissue dissected [illegible]

exposed. An incision one millimetre behind and concentric with the limbus is now made with a fine scalpel into the anterior chamber. If the iris does not prolapse spontaneously when the incision is made iris forceps are carefully passed into the anterior chamber and the iris grasped at ten-thirty, pulled out of the wound and cut radially with iris scissors. It is then pulled free from the angle and the iridectomy completed by a radial incision at one-thirty. The conjunctival flap is finally sutured back into place. Antibiotic drops are put into the eye and a pad and bandage applied.

This operation is nearly always successful in reducing the tension, but the visual results may be disappointing, probably because surgery is usually resorted to only when the condition has been present long enough to cause serious damage to the optic nerve.

Chronic simple glaucoma

Symptoms and signs

Pain and discomfort are minimal in chronic simple glaucoma, and lucky is the patient whose condition is recognized at a routine sight test before extensive loss of visual field has taken place. The onset of the raised intra-ocular pressure is slow and in the early stages is manifest only by an increase in the extent of the normal 2–3 millimetres of mercury diurnal variation, but after some weeks or months the pressure never falls to a normal level at any time of the day, and the nutrition of the optic nerve fibres at the optic disc suffers. The entrance of the optic nerve is the weakest part of the globe and gives way under the increased pressure so that the atrophic changes in the nerve are accompanied by the characteristic cupping of the disc.

Atrophy of the optic nerve fibres leads to defects in the visual fields, but as the process is slow the defect is rarely noticed by the patient until by chance the better eye is occluded or the loss of field extends to the fixation point. The tragedy of this disease is that treatment cannot restore the lost vision and the best that can be hoped for is arrest of the process It is for this reason that early diagnosis is so important, and in some countries mass glaucoma surveys have been undertaken on people over the age of 40 years to detect early cases. Efficient screening methods are now being developed and it is probable that such surveys will become increasingly important in the future

Chronic simple glaucoma usually affects an older age group than congestive or closed angle glaucoma, and one of the earliest signs of this disease is a fatigue of the ciliary muscle causing difficulty in accommodation This may lead the patient to seek more powerful reading lenses, and places great responsibility on the refractionist to recognize the true cause of the symptoms At this early stage the intra-ocular pressure may not be sufficiently raised for digital methods of estimation to be at all reliable, and tonometry combined with careful testing of the central visual field is necessary to make the diagnosis. The optic disc will show pathological cupping and pallor, but this may be difficult to distinguish from physiological cupping.

In physiological cupping the colour of the disc is normal although the bottom of the cup may appear paler than the edges; the lamina cribrosa may be distinguished as a lattice-like pattern and the vessels can be seen along their whole

course over the disc. In pathological cupping the disc is always pale and this pallor includes the disc margin as well as the cup. In advanced cases the cup extends the whole width of the disc and a marked parallax can be obtained between the edge of the cup and the bottom of the cup where the lamina cribrosa is clearly seen. The vessels may disappear out of sight beneath the overhanging margins of the disc.

Diagnosis is easy when both eyes show great depression of vision with corneal oedema due to the raised pressure, deep cupping of the discs and a greatly raised tension. In the early stages, however, the visual fields are the most useful clinical guide. Perimetry may show no abnormality, but if the central fields are carefully tested with a 2-millimetre white object at a distance of 2 metres arcuate defects arising from the disc may be found. Typical early field changes are shown in Fig. 98, which demonstrates how the junction of two arcuate defects produces the so-called "nasal step". Confirmation of the diagnosis at this stage will depend on

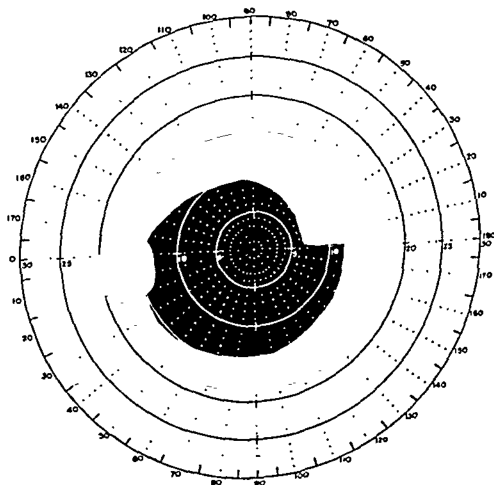


Fig 98.—A typical central field defect in a case of chronic simple glaucoma

the results of repeated measurements of the ocular tension at different times of the day, provocative tests and special measurements of the resistance to outflow of aqueous from the eye.

Water drinking test.—One provocative test which is particularly useful in suspected cases of simple glaucoma is the water drinking test; the patient is persuaded to drink one litre of water on an empty stomach and the effect on the ocular tension measured with a tonometer. A rise of tension of over 5 millimetres of mercury or a maximum tension of over 30 millimetres of mercury during the test is an indication to suspect glaucoma. Theoretically, the imbibition of a large quantity of water is thought to lower the osmotic pressure of the blood and thus increase the osmotic gradient between the aqueous (which is normally hyperosmotic to the plasma) and the blood, so that more water is drawn into the eye; a normal eye is able to compensate for this increase in fluid content, but if the drainage channels are already embarrassed an increase in outflow may not be possible and the tension rises more than in a normal eye.

Tonography.—Tonography is a method of estimating the facility with which fluid can be expelled from the eye and therefore gives some indication of the efficiency of the drainage channels. When a tonometer is placed on the eye it indents the cornea, displacing a volume of fluid which can only be accommodated in the first instance by stretching of the coats of the eye. This causes an increase in the tension in the ocular coats and a rise in intra-ocular pressure. In time aqueous will be squeezed out of the globe by the excess pressure until the intra-ocular pressure returns to normal. The rate at which the tension falls from its initial raised level gives some indication of the resistance to flow of fluid out of the eye. This resistance is known to be greater in chronic simple glaucoma so that such a measurement may be very helpful in diagnosis.

In practice a tonometer is held on the eye for 4 minutes, and from the changes in reading during this time a coefficient of outflow can be calculated. There are, unfortunately, many assumptions in the theoretical basis of this test which apply also to tonometry and which make both tonometry and tonography unreliable in some individual cases. Tonography is, however, a very useful adjunct to diagnosis in many cases and can be used to measure the effectiveness of treatment in improving the drainage of aqueous from the eye.

Treatment

Until the cause of the increased resistance to outflow in chronic simple glaucoma is discovered, treatment will remain empirical and palliative. Miotics may reduce the intra-ocular pressure to normal levels and maintain it so, but in view of the progressive nature of the disease it is not surprising that in time they usually cease to be effective and surgery is required. Conventional surgical methods aim at providing a new outlet for the aqueous humour in the form of an opening through the sclera to connect the anterior chamber with the subconjunctival tissues. There are many technical variations on this theme which may be found in textbooks of ocular surgery. Another method of attack is to reduce the formation of aqueous by applying diathermy to the ciliary body. Though easier to perform and less liable to result in immediate complications, it is a dangerous procedure. The margin between a reduction of aqueous formation to compensate for the reduced

outflow and a reduction to the point where the nutrition of the anterior segment of the eye is insufficient is a very narrow one. This procedure is best reserved for cases which have responded badly to intra-ocular surgery or when the vision in one eye has already been lost. It may also be useful in some types of secondary glaucoma.

The most important aspect about the treatment of chronic simple glaucoma is a careful follow-up of the patient. Repetition of the central fields at frequent intervals combined with measurements of the ocular tension is essential, particularly while the patient is being treated medically.

In patients who cannot be controlled by miotics or surgery, or who refuse surgery, long-term therapy with Diamox in addition to miotics is justified. It is most effective if given in a dose of 250 milligrams daily combined with potassium bicarbonate, 1 gramme 3 times a day (Campbell and his colleagues, 1957).

Results of treatment

An analysis of some recent cases from the author's clinic shows that the prognosis for chronic simple glaucoma is worse than that for the closed angle cases. Many of the cases have quite advanced loss of field before seeking advice or being diagnosed on routine ophthalmological examination.

The author's practice is to attempt to control the patients on miotic therapy which may entail many variations in strength of drug and time of administration. In spite of this 9 out of 32 eyes treated with medical therapy are not completely controlled and will probably require surgery in the near future.

When a miotic regime is unsuccessful a drainage operation is performed and has been successful in controlling the tension in 75 per cent of cases.

These results cannot be considered entirely satisfactory and until we have a better understanding of the underlying pathology are likely to remain so.

Again it must be remembered that no treatment can restore function to atrophic nerve fibres and that the most favourable result of treatment is to prevent further damage taking place.

Congenital glaucoma

There is one other rare type of primary glaucoma—buphthalmos or congenital glaucoma. In this condition there is a congenital failure of differentiation of the tissue which forms the normal angle of the anterior chamber, thus causing an obstruction to the outflow of aqueous. The soft coats of the infantile eye give way under the increased pressure resulting in a large (buphthalmic—"bull-like") eye. Corneal oedema is present and the infant dislikes the light. Examination under anaesthesia will show a corneal diameter greater than the normal 11 millimetres, a raised tension and cupping of the disc. Miotics are of little value and surgery is required. This may be designed to remove the abnormal tissue from the angle to provide an alternative route for the drainage of the aqueous humour.

SECONDARY GLAUCOMA

Here again overproduction of aqueous, although a theoretical possibility, is a rare cause of secondary glaucoma; an obstruction to the flow of aqueous at the pupil

or at the angle is much more common Inflammations of the iris form the largest group, with trauma (including operative) coming next in importance

The treatment of secondary glaucoma is, of course, that of the precipitating condition, but as the raised pressure alone can cause serious visual loss attempts to reduce the pressure are important. It is in this type of case that Diamox is so helpful, as it will bring about an immediate reduction in pressure, allowing more leisurely treatment of the underlying cause Hormonal treatment of acute iritis with corticosteroids has greatly reduced the incidence of secondary glaucoma in this condition by lessening the congestion of the iris tissue which therefore becomes less liable to form adhesions to the cornea or lens.

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ABSTRACTS RELATING TO GLAUCOMA

Changes in ocular tension

Dark-room tests

In a discussion on changes in ocular tension, Foulds (1957) reported on a series of dark-room tests. During the course of the tests the eyes of the patients were anaesthetized with amethocaine hydrochloride and the ocular tension was measured with a standard [illegible] l then the [illegible] 8 patients [illegible] sex com- [illegible] the tests [illegible] luding 17 [illegible]

[illegible] place even in normal subjects. This rise is attributable either to a change in the rate of aqueous flow or to variations in the volume of blood in the uvea. It would seem that if an eye with closed-angle glaucoma shows a tension of more than 25 millimetres the ocular condition is unstable and an acute rise in tension may develop Organic occlusion of the angle is more likely to occur if the eye repeatedly shows tensions in the upper reaches of normality. In these circumstances surgical intervention may be advisable

Applanation tonometry

[illegible]

needed If an elastic globe contains a fluid the pressure in it will be a function of that needed to flatten part of the surface, but if this is to be readily interpreted it is essential that the wall of the globe shall, at least in the part submitted to pressure, be infinitely thin It must also be completely elastic. The cornea, possibly half a millimetre thick and with a certain degree of rigidity, is not of this nature. Furthermore, it lies between two membranes and is bathed in fluid on all sides so that, when anything is used to flatten it, the fluid on its surface develops capillary forces where it is in contact with the instrument. As the cornea is not freely elastic some force is needed to overcome its resistance to distortion, this being needed even when it has no fluid support below. The authors develop formulae which will express the forces needed to overcome the two factors described and it will be remarked that these are present whether or not the globe of the eye is full or empty. They made experiments on the living eye, on eyes recently removed and those taken from the dead body some time before. In 400 normal eyes nearly all had an intra-ocular pressure of $15{\cdot}45 \pm 2{\cdot}52$, this being much below 22 millimetres of mercury. If a pressure of 21 or more millimetres was found steps were taken to exclude glaucoma. Comparisons were made of the readings given by the applanation tonometer and the Schiotz tonometer and it was found that variations in pressure occurred according to whether the sitting or lying position was used. Unless the method permitted a test on a constant area any form of applanation tonometry had a considerable error and tonography with any such appliance is, at the moment, unsatisfactory. If the area compressed has a diameter of between 3 and 3·5 millimetres the various forces hindering a true reading tend to balance out but with such an area chosen it is difficult to alter the intra-ocular tension as the pressure exerted is so low.

Primary glaucoma

Advanced chronic closed angle glaucoma

FOULDS and PHILLIPS (1957) presented evidence that irido-corneal contact as well as goniosynechiae may give rise to an advanced state of chronic closed angle glaucoma with cupping of the optic disc and field loss. *Peripheral iridectomy* is advocated for the relief of goniosynechiae but a drainage operation is required for cases due to irido-corneal contact Goniosynechiae are easily discerned in the angle of an anterior chamber of normal depth. When the angle is narrow, however, differentiation between the two aetiological factors may be difficult So far as the diagnosis is concerned, reliance must be placed upon the history of the case, the response of tension to miotic therapy and the results of provocative tests and outflow estimations A short history and the absence of acute hypertensive episodes are of special significance. As the diagnostic problem is sometimes impossible to solve, it is important to identify cases of closed angle glaucoma long before the establishment of the chronic stage. A successful outcome is almost always achieved when peripheral iridectomy is performed in the early stages of [illegible] result even when [illegible]

mercury. Gonioscopy revealed a very narrow angle. When [illegible] the age of 51 years the right eye showed supero-nasal field loss and a tension of at least 32 millimetres despite the instillation of strong miotic drops. Peripheral iridectomy failed to effect a change in the upper sector of the angle, which must have been closed by goniosynechiae. Subsequently a drainage operation was required.

[illegible] due to a [illegible] s believed [illegible] mulation [illegible] s and the [illegible] quiet and efficient patient is often over-conscientious. The patient [illegible] abandon

this tendency, in the hope of relieving the glaucomatous condition Although of value, the administration of drugs to patients belonging to the younger age groups should be regarded as only an adjuvant In cases of senile involution, however, a high intake of vitamin A is recommended The effects of vitamin A therapy on dark adaptation and on the renal blood flow provide a double justification for the use of the vitamin in cases of glaucoma Only relatively mild exercise should be taken Stooping should be avoided. Attacks of glaucoma may be precipitated by constrictive clothing, by exposure to cold and by the "dark-room" effect of the cinema and television. Morning tea must be forbidden, because the beverage combines the water-drinking test with the caffeine test Beer exerts a deleterious effect, but a small quantity of wine acts as a mild vasodilator.

6½ months Stilboestrol therapy was of assistance in correcting the intra-ocular imbalance when there were concomitant symptoms due to vasomotor disturbances of the menopause The vascular reactivity to adrenaline and nor-adrenaline was tested by means of slit-lamp examination of the conjunctival vessels In this context it is postulated that the therapeutic efficacy of dibenamine in glaucoma is derived from the special power of the drug to block the action of nor-adrenaline As dibenamine must be administered slowly by the intravenous route it is not possible to employ the drug in the routine treatment of glaucoma

Early diagnosis

Roberts (1957) discussed the early diagnosis of primary glaucoma and emphasized the importance of a carefully-taken history The patient should be questioned about the incidence of the disease in the family A note should be made of premonitory symptoms such as transient blurring of the vision, headaches, a feeling of pressure in the region of the eyes and the observation of haloes round lights In the absence of a metabolic disease and of visible changes in the lens, the presence of glaucoma should be suspected if there are frequent changes in the refractive status Anatomical changes include cupping of the optic disc, a very shallow anterior chamber and a narrow chamber angle Routine tonometry should be performed for evidence of an intra-ocular pressure greater than 23 milli-

indication of the degree of scleral rigidity It is important to test phasic variations in tension Priscoline, dark-room and water-drinking provocative tests may be of assistance in the differential diagnosis In cases of closed-angle glaucoma active therapy is needed when pupillary dilatation tests yield positive results Ancillary techniques comprise gonioscopy, studies of the anterior-chamber angle and systematic drawings or photographs of the chamber angle and the optic nerve-head

Management

McLean (1957) stated that early recognition constitutes the first step in the manage-

the angle is wide, corneo-scleral trephination is the operation of choice If the angle is narrow, iridencleisis should be performed provided that there is no evidence of atrophy or fibrosis of the iris tissue Cyclodialysis is employed in cases of aphakic open angle glaucoma Cyclodiathermy, cyclo-electrolysis and retrociliary diathermy may yield poor results An acute attack of angle-closure glaucoma should be treated by means of sedation,

the topical application of strong miotics and the systemic administration of carbonic anhydrase inhibitors Sometimes it may be necessary to employ retrobulbar block and the intravenous injection of hypertonic fluids. Emergency surgery is required if the pressure is not reduced by medical means within 12–48 hours. Basing the criteria upon evidence obtained from tonometry, gonioscopy, tonography, ophthalmoscopy and perimetry, the author divides cases of angle-closure glaucoma into 4 classes. In Class I [illegible]

[illegible] in the management of the relatively severe conditions encountered in Classes III and IV. A single pillar iridencleisis is used in the former class of case and a double pillar iris in- [illegible]

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